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A Summary of Current Program and  
Preliminary Report of Progress

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HORTICULTURAL CROPS RESEARCH

of the

United States Department of Agriculture  
and related work of the  
State Agricultural Experiment Stations

Section A

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE  
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## RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. Farm Resources and Facilities  | 8. Cotton                         |
| 2. Utilization                    | 9. Grain and Forage Crops         |
| 3. Human Nutrition & Consumer Use | 10. Horticultural Crops           |
| 4. Marketing                      | 11. Oilseed, Peanut & Sugar Crops |
| 5. Agricultural Economics         | 12. Plant Science & Entomology    |
| 6. Forestry                       | 13. Tobacco                       |
| 7. Animal and Animal Products     |                                   |

The Source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number pre-fixes shown below refer to advisory committees listed above.

### ORGANIZATIONAL UNIT PROGRESS REPORTS

#### Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Consumer & Food Economics
- 4 - Market Quality
- 4 - Transportation & Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease & Parasite
- 12 - Crops
- 12 - Entomology

#### Economic Research Service (ERS)

- 1, 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development & Trade
- 5 - Foreign Regional Analysis
- 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service  
(SRS)

### SUBJECT MATTER PROGRESS REPORTS

- 6 - Forestry (other than Forest Service)
- 7 - Animal-Poultry & Products Research other than Husbandry, Disease and Parasite
- 8 - Cotton and Cottonseed
- 9 - Grain and Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed and Peanut
- 11 - Sugar
- 13 - Tobacco

A copy of any of the reports may be requested from Axel L. Andersen, Executive Secretary, Horticultural Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

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## INTRODUCTION

This report deals with research related to production, processing, distribution, and use of citrus, deciduous, subtropical, and small fruits; vegetables; edible tree nuts; flowers and nursery plants; woody ornamentals; and trees for shade and farm windbreaks. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other agricultural commodities, as well as horticultural crops. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS, (6) PUBLICATIONS - STATE EXPERIMENT STATIONS.

Research on horticultural crops is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

### Research by USDA

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting, and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Research Divisions of the Agricultural Research Service.

Nutrition, Consumer and Industrial Use Research. Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms or combinations of food products. It is also concerned with improved equipment and processes. The work is done by the Eastern, Southern, and Western Utilization Research and Development Divisions; and under contract with State and foreign country laboratories and in cooperation with industry and other organizations mentioned under program for each research area.

Marketing and Economic Research. Research by the Market Quality Division, Agricultural Research Service, deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

Transportation and marketing facilities research is concerned with methods and material used in marketing and transporting farm and food products from the farm to the consumer. This research is done by the Transportation and Facilities Research Division, Agricultural Research Service.

Research pertaining to marketing economics is conducted by researchers in two agencies. The Farmer Cooperative Service deals with the cooperative aspects of marketing. The Marketing Economics Division, Economic Research Service, conducts studies on the physical efficiency and performance of the marketing system with respect to (a) farmers, (b) marketers, and (c) consumers and transportation and interregional competition. Identification and measurement of relationships affecting supply, demand, and price of horticultural crop and commodity situation and outlook analysis are a part of the research in the Economic and Statistical Analysis Divisions, Economic Research Service.

Research on the behavior, opinions, and preferences of consumers which affect their purchase and use of agricultural products or end products is conducted by the Standards and Research Division, Agricultural Research Service.

#### Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, food container and equipment suppliers, marketing equipment and facility manufacturers, chemical and fertilizer companies, package and container manufacturers, market research institutes and corporations, nurserymen, orchardists, and



producers. Industry's cooperation in supporting research on horticultural crops in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State Stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried horticultural products. The canning, freezing, and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizable contributions to research on the development of equipment for handling horticultural crops on the farm, in orchards, or in greenhouses; into and out of packing houses, transportation vehicles, and wholesale distribution centers; and in the retail establishment. They also conduct research on the containers in which the products are moved and on the transportation vehicles from which it moves from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and intermarket competition.

Chemical, fertilizer, and electrical companies make significant research contributions in the development of new materials, or combinations of materials, to produce more efficiently high quality horticultural commodities, through better plant nutrition; improved disease, insect, nematode, and weed control; and the regulation of growth processes by the use of growth regulator substances and other chemicals, light, and environmental control.

There are a few private breeders of horticultural crops and a number of the larger nurserymen, florists, and seedsmen, who spend considerable time and money in the search for and testing of new varieties in the major production areas, sometimes on their own acreage, but usually in cooperation with some grower. The contribution of growers to our overall research effort on horticultural crops is substantial. Certainly, in the field of production their help is indispensable, for most of the laboratory research results must be finally confirmed by larger-scale experiments. The grower cooperates with the USDA, State Experiment Stations, and suppliers of many materials and equipment, usually without compensation except for the experience and knowledge gained.

Examples of Recent Research Accomplishments  
by USDA and Cooperating Scientists

Recent Research Provides New Labor Saver in Pruning Horticultural Plants.

Most ornamental plants in commercial production must be pruned manually at least once and often several times, an operation that is becoming progressively more costly. Recent research in the Crops Research Division shows that the lower alkyl esters of the C<sub>8</sub> to C<sub>12</sub> fatty acids and C<sub>8</sub> to C<sub>11</sub> fatty alcohols in aqueous emulsions are active on a wide range of horticultural plants by selectively killing the terminal meristems without damaging the axillary meristems, foliage, and stems of the plants. Axillary shoots develop on the sprayed plants at nearly the same time and frequently in greater numbers than on plants pruned manually. The chemicals in suitable concentration appear to be equally effective on herbaceous and woody plants.

New Shrubs for Landscape Use. Five new cultivars, which were developed through an extensive and continuing breeding program to produce superior ornamentals for landscape use, were released to nurserymen. These include Ilex crenata 'High Light', a Japanese holly with boxwood-like foliage and compact, billowy growth habit; Hibiscus rosa-sinensis 'Vulcan' with distinctive, glossy, leathery foliage and brilliant red flowers; Pyracantha 'Shawnee', a yellow-fruited firethorn with resistance to fire blight and scab; and two viburnums, 'Mohawk' and 'Cayuga'.

Sterility methods of control of codling moth. Experimental sterile male releases were used instead of insecticides to control the codling moth in approximately 17 acres of apple orchard in Washington. An overflooding ratio as high as 400 sterile moths to 1 wild moth was achieved. Worm entries were comparatively rare in the release orchard. With the reduced amounts of insecticide employed in the orchard, marked improvement in the effectiveness of biological control of other pests was noted.

Reflective aluminum repels aphids and reduces incidence of aphid-borne virus diseases on vegetables and ornamentals. Insecticides frequently fail to kill insect vectors of plant diseases quickly enough to prevent transmission of the disease organisms. Research, which has been underway since 1963, has demonstrated significant reductions in the incidence of cucumber mosaic, squash mosaic, watermelon mosaic and gladiolus viruses by repelling aphids with aluminum mulches. In 1965 aluminum foil mulches repelled aphids, banded cucumber beetles, and Mexican bean beetles from squash and beans. Flying aphids were reduced 93% in squash planting with aluminum mulch and only 4% of the mulched plants were infected with aphid-transmitted viruses, compared to infection of 69% of the check plants. Yield was increased six-fold in the aluminum plots. Research is being continued to characterize the repellancy properties of reflective aluminum.



Mechanical Harvesting of Red Tart Cherries. A mechanical method of harvesting red tart cherries that was developed by Department scientists and engineers has been commercialized. The method consists of machine shaking of the tree to drop the fruit, which is caught on a padded collecting unit. Five men and one unit can replace 100 cherry pickers. The cost of harvesting by this method is one cent per pound as compared with three cents for hand-picking, and the application by Department scientists of their basic knowledge of the effects of bruising, delay and temperature on cherry quality has eliminated several problems previously connected with the processing of mechanically harvested cherries.

In 1965, 135 machines harvested 25 million pounds of cherries, (7% of the total crop) more than double the previous year's total. At a saving of two cents a pound mechanical harvesting effected a total saving of about \$500,000 in harvesting the 1965 crop. Extended to the entire U.S. crop, mechanical harvesting could mean a total saving of some \$7,000,000 dollars annually at present production levels. The severe shortages of labor for harvesting fruit are expected to accelerate the spread of the mechanical harvesting technique.

Apple Juice Concentration by the Sargeant Process. Virginia Station scientists have applied the Sargeant electronic concentration process to the production and characterization of a high-density apple juice concentrate. A 7.3:1 and higher density apple juice concentrate was produced without development of off-flavors. No technical difficulty was experienced in concentrating apple juice by this method to up to 82 percent soluble solids. The concentrate product reconstituted easily with water to yield a single-strength juice of good organoleptic quality. The process requires the use of additional equipment and therefore is at a disadvantage in this respect.

Quick-Cooking Dry Beans. A simple new process for making convenient quick-cooking dry beans promises to stimulate a much needed expansion in the market for this high-protein food. Research on the product was partially supported by the California Lima Bean Advisory Board. The new product, to be marketed in a dry form, can be prepared for table use in about 30 minutes by cooking in boiling water. The cooked beans have excellent appearance and flavor. Several food manufacturers are interested in using the process, which is applicable to other varieties of dry beans as well as Limas.

OSMOVAC Fruits--Superior Dehydrated Products. Department scientists have developed an entirely new concept for drying fruit. By combining the techniques of osmotic dehydration and vacuum drying, they have produced dried fruits of superior flavor and color. The name OSMOVAC is applied to the process. Fresh fruit, whole or sliced, is covered with dry sugar or a heavy sugar syrup and allowed to stand for a few hours, then it is drained and further dried under vacuum. The sugar removed about 70% of the water in the

fruit. It also protects the color and flavor throughout the process so that no sulfite, as required in conventional dehydration, need be used. The process has been applied to whole and sliced strawberries; sliced bananas; cut apricots; sliced peaches, pears, and papayas; blueberries; and pitted cherries. The dried products are bright and colorful as well as delicious. They are attractive as confections and for use in breakfast cereals. Three major cereal manufacturers are evaluating OSMOVAC dried fruits for possible inclusion in dry breakfast cereals.

Sweeteners from Citrus Fruits. Citrus fruits contain a wide array of complex compounds known as flavonoids, some of which cause bitterness in the juices, particularly in grapefruit juice. While Department scientists were studying the chemistry of these bitter compounds to learn how to process citrus to eliminate this bitterness, they made the important discovery that suitable chemical treatments of the two most abundant bitter flavonoids, naringin and neohesperidin, could reduce bitterness, eliminate it entirely, or even produce sweet-tasting products. Naringin can be converted into a substance as sweet as saccharin, and neohesperidin into one that is 20 times sweeter. The sweetness of both products is pleasant and long-lasting, without the metallic after-taste of saccharin. Over two dozen chemical, pharmaceutical, and food companies have obtained samples and are evaluating these compounds for use as non-caloric sweeteners in such products as dietetic soft drinks and medicines. The method for preparing the sweeteners has been patented by the Department. Work continues on developing a feasible chemical debittering process for citrus juices.

Improved Handling and Shipping Practices Developed for Cantaloups, Lettuce, and Red Tart Cherries. Cantaloups South Texas has an expanding cantaloup industry, due largely to development of a variety adapted to the area. However, marketing has been complicated by surface mold growth on the mature melons that adversely affects appearance and salability and sometimes causes decay. Research at the Harlingen, Texas laboratory has developed a hot water treatment (30 seconds at 135°F.) which cleans up the surface molds and dries the stem scar. During the present shipping season 7 heat treating units have been installed in commercial packing houses. In addition, 2 of the units operated successfully during the spring shipping season in Mexico.

Transportation of lettuce Laboratory studies at Fresno and Beltsville have shown that reduced oxygen in the range of 1 to 5 percent at simulated transit temperatures (33 to 40°F.), substantially reduces russet spotting in susceptible lots of head lettuce as compared with holding in air, during marketing. Shipping tests were conducted to determine low oxygen effects under transcontinental shipment in commercial rail car and van equipment. Comparisons in 8 paired-car and 15 paired-trailer tests included liquid nitrogen refrigeration vs. mechanical refrigeration and mechanical refrigeration supplemented with nitrogen vs. mechanical refrigeration alone. The tests indicated shortcomings in liquid nitrogen-refrigerated equipment which can probably be corrected. Lettuce shipped



under reduced oxygen had less russet spotting but decay at market was related directly to average transit temperature rather than to oxygen concentration. Because of the availability of several types of commercial equipment and the intense industry interest, tests are being continued.

Red Tart Cherries Scald is a troublesome defect in processed red tart cherries. Susceptibility is related to bruise damage to fruit during harvesting and handling and it has increased with mechanized harvesting. Research at Beltsville has shown that oxygen deficiency in soak tanks caused typical scald symptoms to develop in bruised fruits. Aeration equipment was tested under controlled soak tank conditions at a commercial processing plant in Pennsylvania. Scald did not develop on bruised cherries held in water with an oxygen level of 8.6 ppm. This finding if commercially adopted would substantially reduce scald damage in commercial packs.

Improved Shipping Containers for Overseas Shipments of Perishable Products. Cherries, grapes, nectarines, and strawberries were air shipped to Europe in light-weight plastic boxes that reduced per unit air freight charges by 80, 74, 88 and 10 cents respectively. Frozen poultry shipped to Europe in van containers required less costly, lighter weight fiberboard boxes and it was unnecessary to strap individual boxes.

Citrus payment methods under emergency conditions. Immediately following the severe freeze of December 1962, Florida citrus cooperatives began emergency harvest of damaged fruit. Many standard cooperative practices were modified in the process. Under contract with FCS, the University of Florida studied pooling practices in the post-freeze period to evaluate the application of the dual standards of equal treatment and efficient operation. This study helped citrus cooperatives use a modified basis for making pool returns after the January 1966 freeze.

Consumer acceptance of instant sweetpotato flakes. The results of a study acceptance by a panel of consumers of instant sweetpotato flakes, which were developed by the Southern Utilization Research and Development Division, ARS, indicated considerable commercial potential for the new product. This conclusion is similar to that drawn from the results of an earlier study to measure consumer's reactions to instant white potato flakes. The acceptance of the white flakes has been a major contributing factor to halting the downward trend of per capita potato consumption. Since the publication of the final results of the sweetpotato flakes survey, a number of processors have begun producing the sweetpotato flakes.

## Examples of Recent Accomplishments of the State Agricultural Experiment Stations

The Alabama station in research on the sex attractants of the female cabbage looper moth, has isolated and identified an attractive chemical - CIS-7-dodecen-1-d acetate. The chemical structure of the attractant was verified by synthesis of the compound.

Mosquito Oviposition Lure. The Delaware station was successful in the isolation of a chemical substance possessing a high degree of attractiveness to ovipositing female mosquitoes, Culex salinarius, Coq. This attractant material is of protein origin, apparently derived from decaying plant tissues. Early in the investigation it was observed that concentrated straw infusion contained an attractant factor. In field and Laboratory tests, water suspensions containing a proteinaceous extract attracted more ovipositing mosquitoes than did the raw infusion, and significantly more than the native habitat. The oviposition lure which has been isolated should be very useful in the future in highly selective control measures for the mosquito, C. salinarius. The results indicate the way to develop similar lures which would be attractive oviposition sites for other species of mosquitoes.

Imported Parasite Controls California Red Scale. The parasite, Aphytis melinus, was introduced into California from Pakistan. Studies by the California station over the last five years have shown that in many citrus areas of California, particularly near the coast, the parasite has almost completely replaced ineffective parasites of other species and now provides a high and satisfactory degree of red scale control without the use of pesticides.

Parasite Controls Rhodesgrass Scale in South Texas. A microscopic wasp from India, some frozen food cartons and the airplane are being turned against a scale insect that has virtually obliterated Rhodesgrass, a favorite grass of ranchers for many years, and reduced the yield of other grasses in Texas. In some cases, the capacity of pastures was reported to have been reduced by 30 percent. Texas Agricultural Experiment Station entomologists have known the effectiveness of using the wingless wasp to parasitize Rhodesgrass scale for some time. Now, large areas have been needed with grass sprigs infested with scale, which in turn, are parasitized by the wasp. The grass sprigs are dispersed by dropping them in frozen food cartons from low-flying aircraft as in the screwworm eradication program. The parasites emerge from the grass sprigs and attack the scale in the area. Experimental drops have shown remarkable reduction in scale populations and substantial increases in forage yields.

Washing Removes Pesticide Residues. An intensive study of the effectiveness of washing fruits and vegetables with water and various detergents for the removal of certain surface residues, is in progress at the New York State Agricultural Experiment Station. During the past year, preliminary studies were undertaken for the removal of captan, parathion, and methoxychlor from Hudson cherries, DDT from apples, and endrin from cole crops. In all cases significant reductions in the surface residues could be accomplished without alteration of keeping quality of the produce.



New high-solids tomato product developed. A new high-solids tomato product that resists spoilage by yeasts, molds and bacteria and has a greatly extended shelf life has been developed by California researchers. The new product was developed for use by remanufacturers in such items as soups, relish, sauces, Italian dinners and a variety of other products in which tomatoes are an essential ingredient. It can be easily reconstituted to the desired solids content and is economical to transport. In the procedure, fresh canning tomatoes are washed, crushed, and the juice extracted by conventional means. The extracted juice is then concentrated under vacuum to about 50 percent solids, at a temperature low enough to minimize damaging heat effects on the products. From the vacuum concentrates, one method employs a valve which extrudes the concentrated paste through a stream of hot air onto a tray or belt. This extruded product is spaghetti-like in appearance and when the desired degree of dehydration is attained is dry enough to be ground into a powder.

A continuous-crush press developed for the grape industry. California station scientists have developed a new continuous-flow fruit press for wineries. Flexibility of layout, light weight and low power requirements allow the press to be built in a large number of configurations and sizes. Average yields of liquid from grapes increased 9 percent above the conventional basket-pressing method. This machine has been patented and will be produced by commercial manufacturers. Further evaluations of the press are planned with grapes and a variety of other products.

Wine colored by steam passes test. Port wine colored by the steam-heat process developed by California scientists proved to be as good as or better than conventional port. Results indicate that the steam treatment may be useful in all red wine production. The mechanized, high-speed pressure cooker was designed to extract the red skin color from fresh grapes in a hurry and without lowering the quality. Workers found that grapes steam-treated only 15 seconds in the new cooker, easily matched the fermentation-colored wines. Meanwhile, the food industry is showing interest in the mechanical cooker, which looks promising for precooking (blanching) frozen foods.

Onion dehydration studied. Factors required to produce a high-quality dehydrated onion are under investigation at the New York (Geneva) station. High solids content, high pungency, uniform color, large size and globe shape, ease of peeling and storability were factors needed to produce good dehydrated onion products. New York varieties were found to comply with existing color standards suggested by the American Dehydrated Onion and Garlic Association.

Accelerated water-uptake in dry pea beans. An investigation of the water-uptake in dry pea beans (Phaseolus vulgaris) was undertaken by Indiana scientists to explore the possibilities of shortening both the soak process and the thermal process as practiced in commercial canning. Rate of water-uptake increased when adsorbed or trapped gases were released from the surfaces of the beans by steam pressure, vacuum or sonic treatment. Water-uptake rate depended on the thickness of the layer of beans being treated. Certain combinations of polyphosphates and sodium chloride resulted in greater water-uptake than did corresponding concentrations of polyphosphates alone. Lack of sufficient bean tenderness continues to be the main problem in shortening the thermal process. However, beans soaked with both polyphosphates and salt and in less than half the conventional processing time were found to be more tender than conventionally-processed beans.

Commercial Peanut Butter Ice Cream Developed. Research sponsored jointly by the Georgia Agricultural Experiment Station and the Georgia Agricultural Commodity Commission for Peanuts has resulted in the development of a formula and process for commercial peanut butter ice cream. Two commercial ice cream firms in Georgia cooperated in the development. Several firms outside the State evaluated it. Difficulties of moisture absorption and poor texture were overcome by very fine grinding and use of suitable stabilizers

Drying Coffee with Solar Heated Air. The Puerto Rico Agricultural Experiment Station has demonstrated that by harnessing solar heat energy, substantial savings in electricity or fuel costs can be achieved in drying coffee. In some cases heating costs have been reduced by 70 percent. This is achieved by the construction of a solar heat collector on the roof of a processing building. Circulated air, heated in the collector is used in the drying process. This development will be of great value to coffee growers throughout the world since coffee is usually grown in areas where large quantities of solar energy are normally available.

"Instant" Pea and Bean Soups Being Perfected. "Instant" pea and bean soups are being perfected at Michigan State. Made from powdered peas and beans, these soups readily become wholesome, protein-packed foods just by adding water. Agricultural engineers and food scientists are trying to further improve the drying methods since the soups offer intriguing possibilities as inexpensive additions to the menus of underdeveloped countries.

High Temperature "Freezing" Gives Cheaper Fruit Juice. A faster and cheaper method of concentrating fruit juices is being explored by Wisconsin scientist O. R. Fennema. It involves freezing water at temperatures higher than 32° F. Certain compounds will make water molecules attract at temperatures higher than 32° F.--the normal freezing point of water. Freon 11, a common liquid in refrigerators, is such a compound. With the addition of Freon 11, apple juice, which under normal conditions freezes at 28° F., will freeze at temperatures about 15 degrees higher. Since only the water freezes, the unfrozen concentrated juice is separated by centrifugation. The Freon 11 is attached to the water removed from the juice and can be recovered and used again.



Gamma Radiation Offers Promise for Extending the Shelf Life of Citrus Fruit and Reducing Spoilage Losses. Use of gamma radiation treatments for extending shelf life of citrus fruits has been found beneficial by workers of the Florida Agricultural Experiment Station. These scientists point out that there are many causes for citrus fruit spoilage, including stem-end rot, green mold, black rot of oranges and anthracnose. Although citrus fruits are not as perishable as peaches, strawberries and certain other common fruits, a sizeable loss occurs in marketing channels with estimates indicating that from 1959-1963, the retail value of the annual fresh market spoilage losses in the United States for oranges was \$8.4 million and for grapefruit \$5.4 million. The workers state that, while organisms causing decay are inactivated by an adequate exposure to the gamma rays, it is necessary to limit doses so that only minor changes take place in the fruit's texture, flavor, color and respiration. They further point out that the several decay-causing organisms vary in radiation resistance. Thus, no single radiation dose can be stated that will be the minimum needed for protecting citrus fruit against spoilage.

By-Products of Florida Citrus Characterized. The rapid growth in citrus production and processing has brought about a citrus by-products industry. Florida station scientists have developed information on their composition, technology and utilization. For example, citrus molasses which finds its greatest market presently as a feed, as now manufactured in Florida, is required to meet minimum State standards. It must contain 45 percent total sugars, expressed as invert sugar and have a Brix of not less than 35.5° by double dilution. This is typical of the wealth of valuable information compiled for the industry by these workers.

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As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. It comprises a list of the related publications of the State Agricultural Experiment Stations in addition to those heretofore reported covering the results of USDA and cooperative research. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.





## I. FARM RESEARCH

### TREE FRUIT BREEDING AND GENETICS, DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. The fruit industry continually needs new disease-resistant scion varieties with improved horticultural tree and fruit characters and root-stock varieties that are winter-hardy, disease- and nematode-resistant, and which make young trees precocious and more fruitful. More precise information is needed about diseases and its economic control as well as about the basic physiology of fruit setting, fruit thinning, and growth. The best combinations of apple and pear rootstocks and scions to induce precocious and reliable fruit bearing are moot and need comprehensive and systematic evaluation. Valsa canker, a debilitating fungous disease of tree trunks, has been long known and is showing an alarming resurgence in peach areas.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, plant physiologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of fruit growers' problems. Apple breeding research at Lafayette, Indiana, and at Blairsville, Georgia, and cultural and disease research at Wenatchee, Washington, and Arendtsville, Pennsylvania, is cooperative with the respective State Experiment Stations as is pear research at Hood River, Oregon, and Wooster, Ohio. Peach breeding and varietal evaluation research at Fresno, California, is in cooperation with Fresno State College and at Prosser with the Washington Agricultural Experiment Station; disease and cultural research at Clemson is cooperative with the South Carolina Agricultural Experiment Station; at Athens and Experiment, Georgia, it is cooperative with the Georgia Agricultural Experiment Station, and at Davis, California, in cooperation with the California Agricultural Experiment Station. Plum breeding and evaluation research at Fresno is cooperative with Fresno State College and at Prosser with the Washington Agricultural Experiment Station. Cherry breeding and evaluation research at Prosser is cooperative with the Washington Agricultural Experiment Station; and disease research at Logan is cooperative with the Utah Agricultural Experiment Station. Apricot breeding research at Fresno is cooperative with Fresno State College.

Federal stations having deciduous fruit-tree research are Wenatchee, Washington; Fort Valley, and Byron, Georgia; and Beltsville, Maryland. Research at Wenatchee includes variety evaluation of pears; disease research with pear, peach, plum, and cherry; and cultural research with apple and pear. Breeding, variety evaluation, and cultural research is

done with peach at Fort Valley. Research at Beltsville includes breeding and genetic studies of apple, pear, and peach; diseases of apple, pear, and peach; varietal evaluation of peach; and cultural studies of apple and peach.

The following research is being done under extra-mural cooperative agreement: biochemical basis of apple scab resistance at the Indiana Agricultural Experiment Station; cause and control of York spot of apple at the Pennsylvania Agricultural Experiment Station; and, at the Georgia Agricultural Experiment Station, winter injury and the short life of peach trees as well as the replant problem and short life of peach trees.

Twelve P.L. 480 contracts are currently in effect with the: (1) Osmania University, Hyderabad, India, adaptation of fungi to fungicides, (2) Indian Agricultural Research Institute, New Delhi, maintenance and evaluation of genetic stocks of pome and stone fruits; Israel Ministry of Agriculture, Volcani Institute of Agriculture, Rehovot, Israel, (3) physiology of rest (dormancy) and its application to fruit growing, and (4) mineral nutrient balance and its application to fruit growing; (5) Department of Plant Pathology, University of Milan, Italy, etiology and methods of controlling pear Moria (pear decline) in Italy; Research Institute of Pomology, Skierniewice, Poland, (6) evaluation of East-European and Asiatic fruit species and varieties recently introduced into Poland which are of value to the U. S., (7) growth promoting substances and inhibitors in apple trees, (8) growth regulator effects on stem elongation, bud dormancy, and flower initiation of fruit trees, (9) pome and stone fruit virus diseases in Poland, and (10) mineral element and carbon content of young apple trees as influenced by bearing age; (11) Department of Biochemistry, Institute "Jaime Ferran" de Microbiologia, Madrid, Spain, chemical and physiological changes in fungi during autolysis; and (12) Instituto Biologico, Sao Paulo, Brazil, basic biochemistry of crown gall formation.

The Federal scientific effort devoted to research in this area totals 30.7 scientist man-years. Of this number 5.5 are devoted to breeding and genetics; 15.6 to diseases; 1.1 to variety evaluation; and 8.5 to culture and physiology.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 161 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

1. Apple. At Lafayette, Indiana, cooperative research continues on the development of varieties resistant to apple scab (Venturia inaequalis). Approximately 2,100 scab resistant seedlings fruited in 1965, and 3 are being tested as possible varietal introductions. Eight original source



genes for resistance were found to be allelic with the source from M. floribunda.

The apple breeding program at Mandan, North Dakota, was discontinued after two new hardy varieties were introduced. These varieties, Mandan and Dakota, are suitable for growing in the cold and dry areas of the Northern Great Plains.

2. Pear. At Beltsville, Maryland, 12,000 seedlings have now been established in field plantings in an effort to select high quality varieties resistant to fire blight (Erwinia amylovora). To augment the breeding program, 133 accessions of pear species and 714 varieties have been planted. Twelve advanced selections were placed in growers' orchards for evaluation.

3. Peach and nectarine. At Fresno, California, the peach variety Summerset, a very late-ripening variety for areas with long seasons, was introduced. Also the nectarine variety Independence, the first non-patented variety comparable in size and firmness to presently-available patented ones, was released. Seventeen peach and nectarine selections are under commercial trial and 4 are in advanced testing stages.

At Beltsville, screening of all selections for fruit bud hardiness was continued a second year. Good agreement in artificial freezing test of the relative T<sub>50</sub> (temperature required to kill 50% of the fruit buds) or individual seedlings between the two years was evident. Hardier selections will be used as pollen parents in 1966 crosses. Evaluation in 1965 yielded 95 selections, 16 of which were propagated.

4. Sweet Cherries. Germination studies showed the wide-spectrum antiseptic Consan could be used up to 1000 ppm to reduce rot without affecting germination. Lambert seeds picked 2 weeks before fully ripe germinated as well as those from ripe fruit. Over 2,000 buds grown from 276 irradiated Bing cuttings showed 1 with short internodes, 4 with distorted leaves, 1 with swollen shoot and corky bark.

5. Plum and Apricot. At Fresno, 4 plum and 3 apricot selections, under trial for several years, appear to have commercial possibilities and will receive further testing.

Of 174 buds from irradiated Italian prune cuttings, at Prosser, Washington, 5 produced short-internode mutants. The stone fruit breeding program at Mandan, North Dakota, was terminated and plant material distributed to other Federal locations.

## B. Diseases

### 1. Apple

Apple scab (Venturia inaequalis). Resistance gene relationship studies at

Lafayette, Indiana, indicate that there are 4 distinct gene pools responsible for scab resistance. Promising scab-resistant selections have been widely distributed for additional evaluation.

Powdery mildew (Podosphaera leucotricha). At Hood River, Oregon, Morestan gave excellent results when applied at the rate of 1/4 to 1/2 lb/100 gallons. At Beltsville, Maryland, karathane gave excellent control of an epiphytotic in apples. When dimethyl sulfoxide (DMSO) was added, half the amount of karathane gave the same control as karathane alone.

Apple ring russet virus. A considerable amount of fruit was affected with russet ring at Wenatchee, Washington. These may have been partly caused by cool spring weather, but the ring russet virus is known to cause this symptom. Graft transmission of ring russet has been demonstrated on Delicious, Golden Delicious, Early McIntosh, Spitzenburg, Turley, and Yellow Newtown from an infected Delicious tree.

Green crinkle or false sting virus. At Wenatchee, Washington, transmissible forms of the virus are shown to have very slow movement in the orchard under natural conditions. This virus still remains a threat, however, as one form of the virus affected 90 percent of Golden Delicious fruit 3 years after inoculation.

## 2. Pear

Fire blight (Erwinia amylovora). At Beltsville, Maryland, there was very little fire blight during 1965. The lack of fire blight is thought to be related to the drought and poor growing conditions during 1964 and 1965. Ten percent chlorox proved to be as effective and less toxic as a surface sterilant for pruning shears than bichloride of mercury, which has been the standard disinfectant for many years. An intensive study of the bacterial organism is being made and the loss of pathogenicity of the organism in vitro is being studied.

Natural resistance to fire blight was found to be related to biochemical components in leaves. The amount of free hydroquinone and the amount oxidized from arbutin following leaf injury relates to the degree of natural resistance found in 6 clones studied.

Pseudomonas blight (Pseudomonas syringae). Pseudomonas blight was particularly bad at Hood River, Oregon, in the spring of 1965. Up to 50 percent of the blossoms in some orchards were affected. Most of the blossoms affected were killed but those that were not killed produced pitted and misshaped fruit. Pathogenic cultures were used to standardize a screening technique that could be used in testing the effectiveness of bactericides during the period of bloom.

Pear decline virus. At Davis, California, Bartlett pear trees on oriental rootstocks showed accelerated growth the first year following inoculation



with pear decline but reduced growth during the second growing season.

P.L. 480 research of pear Moria (decline) in Italy indicates that Moria is identical with, but has milder symptoms than, pear decline in western North America.

### 3. Peach

Bacterial leaf spot. At Clemson, South Carolina, applications of oxytetracycline during the growing season showed excellent promise in the control of the peach bacterial spot disease. Dodine-captan combination and difolitan resulted in satisfactory control of peach brown rot and scab but not of bacterial spot. The dodine-captan combination was too phytotoxic to peach foliage for further consideration. The form and size of the cuticle projection over peach leaf stomates does not appear to be the basis of resistance to the bacterial spot disease in certain peach cultivars. At Beltsville, Maryland, in field tests under relatively severe disease conditions, oxytetracycline satisfactorily controlled bacterial spot (Xanthomonas pruni) on Rio-Oso-Gem peach without economic injury. The control was further significantly enhanced by adding the biologically inactive solvent dimethyl sulfoxide (DMSO) to the antibiotic sprays. Apparently, DMSO increases penetration and translocation of the active antibiotic. Fruit at harvest time had no detectable antibiotic residue or off-flavor after seven spray applications. The last application was made 43 days before harvest.

Bacterial canker. At Clemson, South Carolina, October pruning of peach trees followed by bacterial inoculation caused tree death. Extensive bacterial canker symptoms were reproduced under field conditions. Soil injections with 1,2-dibromo-3-chloropropane decreased the percentage loss of trees infected with Pseudomonas syringae. Taxonomic studies of 140 isolates are in progress. Phenols are being studied chromatographically to determine nature of resistance. Late fertilization, dormant pruning, and simulated drought did not affect carbohydrate concentration in dormant peach tissues, while early pruning caused significant reductions of starch content. Pruning on November 1 may remove twice as much starch reserves as pruning on January 1. The north side of peach tree trunks contained 50% more sugar and 20% more starch than the south side.

Root and crown rots. At Clemson, South Carolina, orchard observations indicate Nemaguard peach rootstock may have some resistance to attack by pythiaceous fungi. A study is under way in soil temperature tanks to determine the reaction of Nemaguard seedlings in soils infested with several species of Pythium and Phytophthora when the plants are grown at four different temperatures.

Peach mosaic. At Riverside, California, field peach trees infected with peach mosaic virus did not develop disease symptoms or show persistent phytotoxicity when injected with different concentrations of dimethyl

sulfoxide (0.01-0.5M). DMSO did not appear to be a satisfactory solvent for other anti-viral compounds when used against peach mosaic virus in peach trees. In Washington and Grand counties of Utah, surveys show a low level of mosaic. Termination of the control program may increase the incidence.

Peach X-disease. At Wenatchee, Washington, commercial apricot and plum varieties were found to be hosts of X-disease virus; they could act as reservoirs for orchard spread to peach.

#### 4. Plum

Virus diseases. At Wenatchee, Washington, a Laroda plum remained symptomless after numerous inoculations in 1960 and 1961 from a peach tree affected severely by X-disease. This was the first P. salicina cultivar in Washington tests to be completely tolerant to the virus. At Riverside, California, reduced blossoming on Santa Rosa plum trees infected with rusty blotch could not be related to leaf symptomatology.

#### 5. Cherry

Fungous diseases. At Logan, Utah, verticillium wilt gave serious loss of young sour cherry, sweet cherry, and mahaleb trees in orchards following tomatoes. Coryneum blight was serious in Cache Valley peach orchards.

X-disease. At Wenatchee, Washington, commercial apricot and plum varieties were shown to be a potential reservoir for orchard spread of X-disease virus to cherries also. In Utah, spread is rapid within sweet cherry orchards and removal of diseased trees has not curbed the spread. At Logan, 50 sweet cherry varieties and selections are now being tested as sources of resistance to the virus. Two promising varieties are under test as interstocks for Bing and Lambert. Bark ring grafts of mahaleb around sweet cherry branches failed to prevent movement of X-disease to sweet cherry tissues below the graft.

Sour cherry yellows. At Madison and Sturgeon Bay, Wisconsin, the sour cherry yellows program was transferred to full state supervision and the line project terminated.

Miscellaneous virus diseases. Field spread of little cherry virus from flowering cherry to sweet cherry was recorded at Wenatchee, Washington, for the first time. Deacon was found to be the most reliable index host for little cherry virus. A commercially propagated ornamental flowering cherry, Prunus serrulata var. Naden, was found infected with little cherry virus in Washington. Although Gil Peck sweet cherry was mildly affected by twisted leaf virus at Wenatchee, Washington, other varieties of sweet cherry, Duke cherry, almond, and P. davidiana were found to be symptomless carriers of this virus. Badacsoner Riesenkirche, Deacon, and Gil Peck sweet cherry varieties, Kansas Sweet (a Duke) cherry, and a seedling of



P. mackii are symptomless carriers of mottle leaf virus. Although transmitted in an isolate known to contain other viruses, 16 of 23 sweet, sour, and Duke cherry varieties tested at Wenatchee showed symptoms associated with short stem of sweet cherry 1 year after graft-inoculation. Seedlings of P. capuli, P. davidiana, and Lord Lambourne apple were found resistant to infection with rugose mosaic virus. Positive transmission of the Plath spur-type virus to Bing from inoculations in 1964 was found. The sour cherry variety Pl-15, grown elsewhere for its tolerance to sour cherry yellows, proved to be more severely affected by green ring mottle virus than any other cherry variety tested at Wenatchee. Irradiation of Bing cuttings killed most of them and failed to prevent appearance of virus symptoms on those that survived. The severe freeze of December 1964, adversely affected some phases of stone fruit virus research at Wenatchee during 1965.

Surveys conducted in Utah sour cherry orchards during 1965 showed a high incidence of sour cherry yellows and an occasional infection of green ring mottle. Hudson sweet cherry is sensitive to severe strains of rusty mottle virus in Utah and may prove to be the most reliable index host for viruses of this group. The sweet cherry varieties Ulster, Chinook and Rainier appear to be tolerant of rusty mottle virus. All Burbank Black Giant cherry trees used as pollinizers in a Utah orchard have developed leaf symptoms suggestive of necrotic rusty mottle.

Chemotherapeutic research at Wenatchee, Washington, showed that increased chromosome complement of a systemic host of tobacco mosaic virus has no measurable effect on virus titre but increases the virus infectivity and decreases the effect of aza guanine inhibition. Heat treatment inactivation of cherry necrotic ringspot virus in cucumber is reversible. Attempts at purification of cherry necrotic ringspot virus have not been successful.

#### 6. Apricot

An atypical culture of asteroid spot virus has been isolated from apricot in Utah. Mule's ear virus caused leaf but not fruit symptoms, during the first year of infection, in 6 of 19 apricot varieties tested at Riverside, California.

7. P.L. 480 Research. United States-sponsored research in India on adaptation of fungi to fungicides showed that Colletotrichum capsici had no adaptation to mercuric compounds but did increase its tolerance to copper. Research in Brazil on the biochemistry of crown gall formation shows that indole-3-acetic acid (IAA), differentially affected by the crown gall infection and a growth regulator, is oxidized on the chromatogram during analysis and earlier isolated products of metabolism may actually be degradation products.

### C. Varietal Evaluation

1. Apple. At Blairsville, Georgia, some of the 380 apple varieties in the plantings fruited for the first time in 1965 and several varieties looked promising for the area.

2. Peach and nectarine. At Fresno, California, the Dawne and Sun Cloud peach varieties did not appear promising for California conditions. The Stark Delicious nectarine, fruiting for the first time, appeared satisfactory. Because of a colder-than-average winter, bud drop averaged only 3% in 13 varieties.

At Beltsville, Maryland, severe drought conditions hampered evaluations. The Summerset peach ripened again satisfactorily despite its very late ripening season. Amount of blush was marginal. Coronet was very attractive and bore an adequate crop.

3. Apricot. At Fresno, California, a state-sponsored canning test ranked the Department's Castleton and a promising Fresno selection high among other varieties and selections from public and private breeding programs.

4. Plum. At Prosser, Washington, European plums averaged 48 percent, while Japanese plums averaged 19 percent, blossom-bud survival after winter.

### D. Culture and Physiology

#### 1. Apple

Nutrition. At Wenatchee, Washington, magnesium deficiency is becoming more prevalent in central Washington orchards. Orchards most seriously affected were mapped and sprayed with different magnesium foliar sprays.

Rootstocks. At the Wenatchee, Washington, rootstock planting, yields per tree during 1965 indicate that in young plantings Golden Delicious is more productive than Red Delicious, and non-spur types are more productive than spur types. The relative amounts of phenols and carbohydrates that accumulate on dwarfing virus seedling rootstocks are studied as they relate to tree size, early bearing, and total production.

Chemical thinners. At Wenatchee, Washington, lanolin bands containing two levels of Sevin (carbaryl) were applied to stems of young developing fruit. The results on Red Delicious were that a high percentage of the fruits dropped and those that remained were seedless; with Golden Delicious more of the young fruit dropped and no seedless fruit remained on the tree.

Night temperature effect on developing fruit. At Wenatchee, Washington, trees in cages were maintained at constant temperatures at night to determine the effect of temperature on developing fruit. Cool nights



early in the season and near the end of the season reduced fruit size. Cool nights promoted color development in both Red Delicious and Golden Delicious. Cool night temperatures had no apparent effect on fruit set or vegetative growth.

Growth retardants. Three years' results with Alar (N-dimethyl amino succinamic acid) show that this growth retardant consistently reduces shoot growth when the chemical is applied at the rate of 1000 ppm 10-14 days after bloom. This application also reduces watercore, prolongs the storage life of the fruit and causes heavier return bloom in the spring. With C<sup>14</sup> labeled Alar, it was found that when applied as a foliar spray, Alar breaks down very slowly and very few other compounds are labeled from its breakdown sequence.

Development of watercore. At Wenatchee, Washington, sugars and sugar alcohols in developing fruit were related to the development of watercore at the time of harvest. The exact relationships have not yet been determined.

P.L. 480 Research. In a final report of research in Poland on growth promoting substances and inhibitors in apple trees a phenolic glucoside-phloridzin was described in dormant buds but in even higher concentration in growing buds and young leaves. The substance oxidized readily to phloretin in alcohol extracts but did not do so in the plant.

## 2. Pear

Growth retardants. Foliar sprays of Alar (N-dimethyl amino succinamic acid) increased the number of flower clusters on young pear seedlings of flowering age at Beltsville, Maryland. The chemical had very little effect in non-flowering seedlings.

Juvenility. At Beltsville, Maryland, matched non-flowering branches were scored and girdled to study the effect on flower bud formation. Foliar applications of chemical sprays were also used to study flowering in non-flowering seedlings.

## 3. Peach

Rootstocks. At Fresno, California, Nemaguard and a Nemaguard derivative with apparent immunity to the incognita nematode, appear compatible with certain varieties of plums. Nemaguard has become the leading resistant stock for peaches, nectarine and almonds. Two homozygous red-leaved selections from Nemaguard appear promising but homozygous nematode resistance needs to be selected out of these.

At Beltsville, Maryland, greenhouse nematode tests were conducted on seedlings of 15 Nemaguard derivatives from the Beltsville and Fort Valley breeding programs. High resistance to both *acrita* and *javanica* nematodes was found in 9 of the groups. A Nemaguard x Okinawa group of seedlings did not give

promising material. Additional groups of seedlings from promising stocks developed at Beltsville and Fresno are growing for greenhouse tests.

Winter-hardiness. At Fort Valley, Georgia, a 4-year study of winter temperature effects showed correlation of tree injury with abnormally warm weather after the chilling requirement of the trees had been fulfilled followed by a sharp drop to below-freezing temperatures. Damage did not occur in one relatively cool winter when temperatures lower than those giving injury in other years were encountered before appreciable movement of tissues occurred.

Chemicals to increase hardiness and thin fruit. At Beltsville, Maryland, artificial hardiness tests on Santa Rosa and Methley plum using decenyl succinic acid for increasing hardiness of buds or blossoms failed to show any consistent increase in hardiness. Addition of DMSO to increase penetration of DSA also failed to give any appreciable hardiness.

Dormancy and Rest. United States sponsored P.L. 480 research in Israel on the physiology of rest and its application to fruit growing shows that peach, like other deciduous trees, responds to light and temperature differentially by variety. The data, however, is more precise than that already available. Both light and chilling effect growth by activating or blocking growth regulator systems within the buds.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Breeding

None

##### Diseases

- Buxton, J. A., J. H. Cochran, R. J. Ferree, H. H. Foster, W. C. Nettles and D. H. Petersen. 1966. Peach pest control - A guide for South Carolina peach growers. S.C. Ext. Circ. 360.
- Cochran, L. C. 1966. Viruses (invitational paper). Proc. Nat'l. Conf. on Peach 167-169. Rutgers Univ.
- Keil, H. L. 1965. Protecting trees. In Consumers All, The Yearbook of Agriculture 1965: 256-260.
- Keil, H. L. 1965. DMSO shows great promise as carrier of agricultural toxicants. Agric. Chem. 20: 23-27.
- Keil, H. L., B. C. Smale, and R. A. Wilson. 1965. Control of peach bacterial leaf spot with sprays of oxytetracycline plus dimethyl sulfoxide (Abstract). Phytopath. 55: 505.
- Keil, H. L., B. C. Smale, and R. A. Wilson. 1966. Role of injury and longevity of Erwinia amylovora in the epidemiology of the fire blight disease of pears. Phytopath. 56: 464-465.
- Kirkpatrick, H. C., G. I. Mink, and R. C. Lindner. 1965. Purification of a second mechanically transmissible virus latent in apple. Phytopath. 55: 286-290.



- Miller, C. R., W. M. Dowler, D. H. Petersen and R. P. Ashworth. 1966. Observations on the mode of infection of Pythium ultimum and Phytophthora cactorum on young peach roots. Phytopath. 56: 46-49.
- Petersen, D. H. 1966. Bacterial canker of peach (invitational paper). Proc. Nat'l. Conf. on Peach 158-159. Rutgers Univ.
- Petersen, D. H. and W. M. Dowler. 1965. Bacterial canker of stone fruits in the Southeastern states. Plant Disease Reporter 49: 701-702.
- Pine, T. S. 1965. Host range and strains of peach mosaic virus. Phytopath. 55: 1151-1153.
- Pine, T. S. 1966. Further observations on mule's ear disease of peach. Plant Disease Reporter 50: 64-65.
- Pine, T. S. 1966. Increased terminal growth of pear trees graft-inoculated with pear decline virus. Phytopath. 56: 150-151 (Abstract).
- Wadley, B. N. 1966. Apricots as hosts of stone fruit viruses (Abstract). Phytopath. 56: 152.
- Wadley, B. N. 1966. Apricot pucker leaf, a virus-induced disorder. (Abstract). Phytopath. 56: 152.
- Williams, M. W., and N. R. Benson. 1966. Transfer of C<sup>14</sup> components from Psylla pyricola (Foer) to pear seedlings. J. Insect Physiol. 12: 251-254.

#### Variety evaluation

- Fogle, H. W. 1966. Peach varieties, breeding objectives and needs in the Pacific Northwest. Proc. Nat'l. Conf. on Peach 1-3. Rutgers Univ.
- Fogle, H. W. 1966. Trends in the Peach industry. Proc. Nat'l. Conf. on Peach 221-224. Rutgers Univ. (Also Business Farming 37(6): 18-20).
- Toyama, T. K., and G. E. Barnard. 1965. The effect of the December, 1964 freeze on some stone fruit varieties and selections. Proc. Wash. State Hort. Assn. 61: 51-53.
- Toyama, T. K. 1965. New stone fruit varieties. Proc. Wash. State Hort. Assn. 61: 39.

#### Culture and physiology

- Batjer, L. P. 1965. Horticultural Science and its application (Presidential Address). Proc. Amer. Soc. for Hort. Sci. 87: 579-585.
- Batjer, L. P. and George C. Martin. 1965. The Influence of Night Temperature on Growth and Development of Early Redhaven Peaches. Proc. Amer. Soc. for Hort. Sci. 87, p. 139.
- Brooks, H. J., H. W. Fogle, and J. W. McKay. 1965. Progress and problems in tree fruit and nut production. Advances in Agron. 17: 283-326.
- Cochran, L. C. 1965. Fruit trees. In Consumers All, The Yearbook of Agriculture 1965: 253-256.
- H. W. Fogle. 1965. Progress and problems in tree fruit and nut production: Stone fruits. Advances in Agron. 17: 295-312.
- Martin, G. C. and William Lopushinsky. 1966. Effect of N-dimethyl amino succinamic acid (B-995), a growth retardant, on drought tolerance. Nature 209: 216-217.

- Pieniazek, J., and L. S. Jankiewicz. 1965. Acropetal and basipetal transmission of 6-benzylaminopurine effect in dormant apple seedlings. Bul. de l'Academie Polonaise des Sciences. Cl. V. - Vol XIII, No. 10 (Series des sciences biologiques): 607-609. (Supported by PL 480 funds).
- Samish, R. M., S. Lavee and A. Erez. 1962. The physiology of rest and its application to fruit growing. Nat. and Univ. Institute of Ag (Israel) Spec. Bul. 45. 37 pp. (Also Spec. Bul. 68, 32 pp., 1964: Pamphlet 96, 21 pp., 1965. (Supported by PL 480 funds).
- Toyama, T. K. 1965. Pollinizers: every third tree in every third row. Proc. Wash. State Hort. Assn. 61: 13-17.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Badr, Sayed and Julian C. Crane. 1965. Growth of Unpollinated Ovaries of Several Deciduous Fruit Species. Proc. ASHS. Vol. 87, p. 163. (Calif.)
- Bukovac, Martin, J. 1965. Some factors Affecting Absorption of 3-Chlorophenoxy-a-Propionic Acid by Leaves of the Peach. Proc. ASHS. Vol. 87, p. 131. (Mich.)
- Carlson, R. F. 1965. The Effects and Relationships of Intermediate Stem Sections on Growth and Behavior of Apple Cultivators. Proc. ASHS. Vol. 87, p. 21. (Mich.)
- Carlson, R. F. 1965. Responses of Malling Merton Clones and Delicious Seedlings to Different Root Temperatures. Proc. ASHS. Vol. 86, p. 41. (Mich.)
- Claypool, L. L., R. B. Fridley, and P. A. Adrian. 1965. Horticultural Aspects in Mechanization of Cling Peach Harvesting. Proc. ASHS. Vol. 86, p. 152. (Calif.)
- Corgan, J. N. 1965. Seasonal Change in Naringenin Concentration in Peach Flower Buds. Proc. ASHS. Vol. 86, p. 129. (New Mex.)
- Crane, J. C. and K. Uriu. 1965. The Effect of Irrigation on Response of Apricot Fruits to 2,4,5-T Application. Proc. ASHS. Vol. 86, p. 88. (Calif.)
- Cummings, G. A. 1965. Plant and Soil Effects of Potassium and Magnesium Fertilization of Elberta peach Trees. Proc. ASHS. Vol. 86, p. 141. (N.C.)
- Cummings, G. A. 1965. Effect of Potassium and Magnesium Fertilization on the Yield, Size, Maturity, and Color of Elberta Peaches. Proc. ASHS. Vol. 86, p. 133. (N.C.)
- Edgerton, L. J. and M. B. Hoffman. 1965. Some Physiological Responses of Apple to N-dimethyl Amino Succinamic Acid and Other Growth Regulators. Proc. ASHS. Vol. 86, p. 28. (N.Y.)
- Feldstein, Joshua and Norman F. Childers. 1965. Effects of Irrigation on Peaches in Pennsylvania. Proc. ASHS. Vol. 87, p. 145. (N.J.)
- Fisher, V. J. 1965. The Effect of Weed Control by Isocil and Bromacil on Growth of Young Peach and Apple Trees. Proc. ASHS. Vol. 86, p. 148. (Del.)
- Fucik, J. E. and J. S. Titus. 1965. Split Root Studies on Calcium and Manganese Absorption and Translocation in Seedling Apple Trees. Proc. ASHS. Vol. 86, p. 12. (Ill.)



- Hansche, P. E. and R. M. Brooks. 1965. Temporal and Spatial Repeat-abilities of a Series of Quantitative Characters in Sweet Cherry (Prunus avium L.). Proc. ASHS. Vol. 86, p. 120. (Calif.)
- Kwong, S. S. 1965. Potassium Fertilization in Relation to Titratable Acids of Sweet Cherries. Proc. ASHS. Vol. 86, p. 115. (N.Y.)
- Lott, Richard V. 1965. The Quality, Color, and Keepability Characteristics of a Low-Acid Jonared Apple Sport. Proc. ASHS. Vol. 87, p. 47. (Ill.)
- Olez, Hayati, and Quentin B. Zielinski. 1965. Pollen Incompatibility Between Bartlett and Seckel Pears. Proc. ASHS. Vol. 87, p. 117. (Ore.)
- Pillay, D.T.N., and L. J. Edgerton. 1965. Relationship of Growth Substances to Rest Period and Germination in Mazzard Cherry Seeds. Proc. ASHS. Vol. 86, p. 108. (N.Y.)
- Pillay, D.T.N., K. D. Brase, and L. J. Edgerton. 1965. Effects of Pre-Treatments, Temperature and Duration of After-Ripening on Germination of Mazzard and Mahaleb Cherry Seeds. Proc. ASHS. Vol. 86, p. 102. (N.Y.)
- Ryugo, K. 1965. The Effect of Seed Excision on the Amount of Darkening in Pollination Variant Persimmons, Diospyros kaki. Proc. ASHS. Vol. 86, p. 297. (Calif.)
- Simon, R. K. 1965. Nutritional Status of Apple Trees in Relation to Location of Sample, Date, Variety and Irrigation. Proc. ASHS. Vol. 86, p. 55. (Ill.)
- Simon, Roy K., and Richard V. Lott. 1965. The Effect of Early-season Hail Injury on the Morphological and Anatomical Development of Peaches. Proc. ASHS. Vol. 87, p. 154. (Ill.)
- Sullivan, D. T. 1965. The Effect of Time of Bloom of Individual Flowers on the Size, Shape and Maturity of Apple Fruits. Proc. ASHS. Vol. 87, p. 41. (New Mex.)
- Titus, J. S., and P. B. Catlin. 1965. Uptake and Translocation of Urea-C<sup>14</sup> Supplied to Roots of Apple Trees. Proc. ASHS. Vol. 86, p. 1. (Ill.)
- Westwood, M. N. 1965. A Cyclic Carbonate and Three New Carbamates as Chemical Thinners for Apple. Proc. ASHS. Vol. 86, p. 37. (Ore.)
- Zielinski, Q. B., F. C. Reimer, and V. L. Quackenbush. 1965. Breeding Behavior of Fruit Characteristics in Pears Pyrus communis L. Proc. ASHS. Vol. 86, p. 81. (Ore.)
- Davis, J. R. and Harley English. 1965. A Canker Condition of Peach Seedlings Induced by Chilling. Phytopathology 55, pp. 805-806. (Calif.)
- English, Harley and J. R. Davis. 1965. Apricot Dieback Fungus Found on Western Choke-Cherry. Plant Disease Reporter 49, p. 178. (Calif.)
- Schroth, M. N. and D. C. Hildebrand. 1965. B-glucosidase in Erwinia amylovora and Pseudomonas syringae. Phytopathology 55, pp. 31-33. (Calif.)
- Schroth, M. N. and D. C. Hildebrand. 1965. Some Differences in the Arbutin-hydroquinone Complex Between Fireblight-resistant and -susceptible Pyrus spp. Phytopathology 55, p. 1075. (Calif.)
- Schroth, M. N., E. J. Ford, and D. C. Hildebrand. 1965. Localization of Arbutin in Pyrus by Means of Alkaline p-phenylenediamine. Stain Technology 40, pp. 245-248. (Calif.)
- Lister, R. M., J. B. Bancroft, and M. J. Nadakavukaren. 1965. Some Sap-Transmissible Viruses from Apple. Phytopathology 55, pp. 859-870. (Ind.)

- Agrios, G. N. 1965. Differential Growth of Certain Pathogenic Fungi on Extracts from Virus-Infected and Virus-Free Apple and Pear Tissues. *Phytopathology* 55, p. 127. (Mass.)
- Agrios, G. N. 1965. Fruit Russet Ring and Leaf Flecking Virus on McIntosh Apple in Massachusetts. *Plant Disease Reporter* 49, pp. 314-318. (Mass.)
- Goodman, R. N. 1965. In vitro and in vivo Interactions Between Components of Mixed Bacterial Cultures Isolated from Apple Buds. *Phytopathology* 55(2), pp. 217-221. (Mo.)
- Voros, J. and R. N. Goodman. 1965. Filamentous Forms of Erwinia amylovora. *Phytopathology* 55(8), pp. 876-879. (Mo.)
- Millikan, D. F., Guengerich, H. W., and R. N. Goodman. 1965. Gummosis and Leaf Spotting of Sweet Cherry Symptoms Associated with Bacterial Infection. *Plant Disease Reporter* 49, p. 381. (Mo.)
- Afanasiev, M. M. and R. I. Hamilton. 1965. "Short-Stem" Virosis of Sweet Cherries. *Plant Disease Reporter* 49(3), pp. 253-255. (Mont.)
- Gilmer, R. M. 1965. Additional Evidence of Tree-to-Tree Transmission of Sour Cherry Yellow Virus by Pollen. *Phytopathology* 55, pp. 482-483. (N.Y.)
- Mink, G. I. and J. L. Parson. 1965. The Prevalence of Some Latent Viruses in Sweet Cherry Trees of Various Age Groups in South Central Washington. *Plant Disease Reporter* 49, pp. 143-145. (Wash.)



SMALL FRUIT BREEDING AND GENETICS, DISEASES, VARIETY  
EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Present varieties of small fruits and grapes lack broad regional adaptation suitable for modern commercial use. Needs include large (for ease of picking), firm-fruited (for best handling, etc.), disease-resistant varieties for freezing and for long distance or local marketing, with a sequence of ripening throughout the season. Causal agents of new diseases must be identified, and methods developed for effective and economical control of important fungus, nematode, and virus diseases of berries and grapes, with emphasis on identification and control of viruses in strawberries, raspberries, and grapes. Existing information on environmental factors limiting production and on inter-relationships of temperatures, soil moisture, diseases, and nutrition on plant growth, hardiness, and productivity is inadequate for the cultural practices in propagation and plantation management that will result in high production of good quality fruit and reduced production costs.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of growers' problems. The following research is cooperative with the experiment stations and institutions indicated: European bunch-grape breeding, disease, varietal evaluation, and cultural research at Fresno, California, with the Fresno State College; Strawberry breeding research at Salisbury, Maryland; Willard, North Carolina; and Corvallis, Oregon, with the respective State Experiment Stations; and in addition, strawberry breeding and cultural work at Carbondale, Illinois, with Southern Illinois University; Raspberry and blackberry breeding research at Corvallis, Oregon, and Carbondale, Illinois, with the Oregon Agricultural Experiment Station and Southern Illinois University, respectively; Blackberry cultural research at Corvallis, Oregon, with the Oregon State Agricultural Experiment Station; Blueberry breeding research at Gainesville, Florida; Tifton, Georgia; Jonesboro, Maine; and Ivanhoe, North Carolina; and breeding and disease research at Hammonton, New Jersey, and Raleigh, North Carolina, with the respective State Experiment Stations; Cranberry breeding research at East Wareham, Massachusetts; and disease research at New Brunswick, New Jersey, with the respective State Experiment Stations.

Breeding research (strawberries and raspberries) is done at the USDA Horticultural Field Station, Cheyenne, Wyoming. At Beltsville, Maryland, breeding, variety evaluation, and disease research is done with Eastern bunch grape, strawberry, blackberry, blueberry; and cultural studies are done with the Eastern bunch grape, blueberry, blackberry and strawberry.

Grant supported research on the biochemical nature of resistance of strawberries to red stele fungus is done at Boyce-Thompson Institute, Yonkers, New York; and on strawberry resistance to mites is done at Lexington, Kentucky, cooperative with the Kentucky Agricultural Experiment Station and jointly grant supported by the Crops Research Division and Entomology Research Division.

The following research is being done under extra-mural cooperative agreement: Improvement of blueberries at the New Jersey Agricultural Experiment Station; and inheritance of cane canker resistance in blueberries at the North Carolina Agricultural Experiment Station.

Two 5-year PL 480 contracts were initiated: (1) with the Research Institute of Pomology, Skierniewice, Poland, physiology and biochemistry of fruiting in strawberry; and (2) with the Agricultural Institute of Slovenia, Ljubljana, to collect and evaluate indigenous wild fruits and breed small varieties with a high vitamin-C content.

The Federal scientific effort devoted to research in this area totals 15.0 **scientist** man-years. Of this number, 6.1 is devoted to breeding; 7.2 to diseases; 1.3 to variety evaluation; and 0.4 to culture.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 71 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and genetics

##### 1. Grape

American bunch grapes. The principal objective is breeding for disease resistance, especially black rot. From the work at Meridian, Miss., 7 selections that are tolerant of black rot and Pierce's disease virus have been distributed to several experiment stations for further testing.

European bunch grapes (Vinifera). Three seedless and 3 seeded table grape selections are under commercial trials with growers for final determination of their suitability as varieties.

Muscadine grape. The major objective in muscadine grape breeding is origination of perfect flowered varieties adapted to southern growing conditions. Four selections from the work that appear promising as potential varieties are not under extensive tests. Attempts to breed muscadine at the tetraploid level were unsuccessful because of weak, slow growing, and unproductive seedlings.



Grape rootstocks. Rootstock selection 16-154 was named Harmony and released to growers and nurserymen. It has proved superior in one or more respects to the leading rootstocks used in the San Joaquin Valley, California. The variety was obtained by a controlled cross between a seedling selection of 1613 (Solonis x Othello) and a seedling selection of Dogridge.

2. Strawberry. Disease resistance is the major objective in the breeding work at Beltsville, Salisbury, Carbondale, Corvallis, and Willard. Five advanced selections were propagated and distributed for extensive regional testing in North Carolina.

In Maryland, six of the most advanced selections appear very promising and have been propagated and distributed for extensive testing. These are Md-US 2856, 2915, 2921, 3068, 3184, and 3204. Three selections obtained 2 years ago that are resistant to red stele race A-5 may be of commercial caliber.

At Carbondale, of the advanced selection, SI US 169 appears promising as a late berry for home garden use.

At Corvallis, a few selections for resistance to red stele appeared satisfactory, including 2931, which was outstanding in frozen pack. Selection US-Ore 2575 was introduced under the name of Hood. Hood is a processing type berry that is particularly good in frozen pack for the preserve trade. It is resistant to mildew and verticillium wilt and tolerant of red stele and viruses.

3. Raspberry. Raspberry breeding at Corvallis and Carbondale continued along previous lines with emphasis on breeding for disease resistance. At Carbondale, seed has been obtained from controlled crosses aimed at breeding for resistance to viruses using Scottish material as resistant parentage. NC 223 red raspberry was propagated and placed on test in 10 different States in the south-central part of the United States.

4. Blackberry. Major objectives in the work at Beltsville, Carbondale, and Corvallis are to originate varieties of thornless, winter hardy, productive blackberries that ripen in sequence from early to late in the season. At Beltsville, the US 1493 was introduced under the name of Smoothstem and US 1503 was introduced as Thornfree. These are thornless selections recommended for eastern United States that are moderately winter hardy and productive and have satisfactory fruit quality. Other promising selections include US 1482, US 1523 and US 1526.

5. Blueberry. Major objectives remain unchanged but more emphasis is being placed on consistent yearly yields. New work is being initiated in cooperation with the North Carolina station on inheritance of resistance to blueberry cane canker.

At Beltsville, 1 diploid species V. atrococcum, noted for its earliness, was doubled in chromosome number with colchicine. The flowers of this artificially produced tetraploid were fertile and 87 seedlings were obtained in a cross with Earliblue.

In New Jersey, 5 advanced selections appear very promising as potential varieties; namely, G-85, G-99, G-100, G-107, and G-111. The Darrow variety introduced last year was unconditionally released as being substantially free of red ringspot virus. A collection of species was made at New Brunswick and several crosses between species was attempted.

At North Carolina, the NC 690 has been propagated for extensive testing. Three recent rabbiteye selections appear promising. Twenty-one wild clones have been selected for high resistance or immunity to cane canker and these are to be used in new breeding work.

In Georgia, the T-65 rabbiteye continues to appear promising.

6. Small fruits for the Great Plains. Work at Cheyenne, Wyoming, is aimed at origination of strawberry and raspberry varieties for the Great Plains and Intermountain Region which must be winter hardy with short season of ripening. Four advanced strawberry selections have been distributed for test in Iowa, New York, North Dakota, South Dakota, Kansas, and Maryland. Raspberry breeding yielded approximately 2,000 seedlings from controlled crosses between a Wyoming native summer fruiting raspberry clone and commercial varieties.

## B. Diseases

### 1. Grape.

Virus diseases. Eight viruses occur in grapes in California. Their detection by indicator methods, the effects of virus complexes, establishment of virus-free stocks and heat treatments for inactivation of virus are the main problems in the research work. A 28-day heat treatment at 100°F. inactivated fanleaf virus in the tips of grape plants. A 45-day heat treatment inactivated astroid mosaic and yellow vein viruses in stem tips of grapevines and a 56-day treatment freed stem tips in most cases of leaf roll virus. A 60-95 day treatment inactivated corky bark in some stem tips of grapes. Four rootstocks and 30 scion varieties or selections were added to the virus-free foundation vineyard at Davis for propagation purposes. Foliar sprays of 2,4-D amine applied to vines in late August or early September killed roots to a depth of 50 cm and therefore left no residue for nematode vectors to feed on. A test planting has been established with 3 grape varieties that were inoculated with mild and severe fanleaf to determine whether cross protection occurs.



## 2. Strawberry.

Virus diseases. At Corvallis, plants from axillary crown buds excised 3 weeks or later after heat treatment were infected but those excised before 2 weeks were virus-free. Several clones of wild F. chiloensis were found to be highly tolerant of a severe yellows virus complex but none were immune. Several clones of F. ovalis and F. vesca that were collected from the Rogue River Valley in Oregon were found to be free of viruses when indexed. Thirty-three percent of the new US-Oregon selections made in 1965 from plants grown in the field in 1964 and the spring of 1965 were 100 percent viruliferous, indicating a rapid spread of virus into the strawberry plantings in the plots at Corvallis. At Beltsville, preliminary results indicated that latent C virus may be eradicated by tip culture technique but not by the axillary bud technique.

Fungus diseases. From the survey work for red stele in Oregon and Washington, a third new race has been designated A-9. Surecrop was found infected with red stele in the spring of 1964 in a field in Maryland and one in New Jersey which proved to be race A-5.

## 3. Raspberry and blackberry.

Virus diseases. Detection of raspberry and blackberry virus diseases and procurement of virus-free Rubus stocks continue as the major objectives in the present work. Virus-free Latham plants have produced 2 to 3 more canes per acre than virus-infected plants in commercial nurseries in New York. Sixty percent of the raspberry clones tested for viruses contained mechanically transmissible virus when tested on the Chenopodium quinoa. Most of the leading black raspberry stocks are fully infected. Perhaps 3 separate viruses are involved in the mechanically transmitted viruses. Two of these were found to be seed-borne in black raspberry. Heat treatment of stocks at 38°F. for several weeks did not inactivate the virus present in the New Logan variety.

Fungus diseases. Phytophthora megasperma was found associated with the wet soil root rot of red raspberries in Washington State.

## 4. Blueberry and cranberry.

Virus diseases. The control of blueberry viruses continues to be the major problem in the blueberry and cranberry disease work. Roguing of nursery plants infected with red ringspot virus was not fully effective in eliminating the virus from plantings. Heat treatment of infected plants for a 2 or 3 week interval did not eliminate the red ringspot virus. Treatments of 4 weeks and longer may be effective but more time is needed for possible development of symptoms. Application of an insecticide every two weeks from April 1 to November 1 in a commercial nursery planting in New Jersey appears to have prevented infection of the plants with red ringspot virus. The vector has not been determined.

Fungus diseases. An air-ground machine (vehicle supported off the ground by an air cushion) was satisfactory for applying fungicides to cranberry bogs and did not damage cranberry vines, flowers, or fruit. The practicality of the machine is still to be determined.

Inoculation of cranberry fruits with the fungus Glomerella cingulata increase the blossom blast and decreased fruit set. High nitrogen nutrition increased cranberry fruit rot as did high potassium high sulfur. High potassium-low sulfur seemed to decrease rot in cranberries.

### C. Culture and physiology.

1. Grape. Shading of grafts after planting and a well-developed callus at the union aided in the survival of bench grafts. A 2-inch long scion piece was as satisfactory as a longer piece and grew more rapidly than a shorter one. Rooting hormones were of no benefit to graft or cutting survival.

2. Blueberry. More than 50 percent of blueberry softwood cuttings 1-inch long produced plants when propagated under intermittent mist in the greenhouse. The method offers promise for rapid propagation of scarce blueberry material. A replicated test for magnesium nutrition studies was established in a commercial planting in New Jersey.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Breeding

Scott, D. H., I. C. Haut, R. C. Blake, and R. H. Converse. 1965. Sunrise, a new red stele resistant strawberry variety. Fruit Var. & Hort. Digest 19:53-55.

Galletta, G. J., and D. H. Scott. 1965. Earlibelle, a new fresh market strawberry variety for the Southern United States. Fruit Var. & Hort. Digest 19(4): 68-69.

### Diseases

Converse, Richard H. 1965. The reliability of leaf grafting to Rubus henryi for the detection of two viruses of the raspberry mosaic complex. Phytopath. 55: 276-280.

Converse, Richard H., and C. D. Schwartz. 1965. Phytophthora sp. from Washington pathogenic on roots of red raspberry (Abstract). Phytopath. 55: 503.

Goheen, A. C., and Wm. B. Hewitt. 1964. Rivista di Patologia Vegetale, Ser. 3, 4: 427-442.

Golden, A. Morgan, and R. H. Converse. 1965. Nematodes on raspberries in the Eastern United States. Plant Disease Reporter 49: 987-991.



- McGrew, J. R. 1965. Eradication of latent C virus in the Suwannee variety of strawberry by heat plus excised runner-tip culture. *Phytopath.* 55: 480-481.
- Miller, P. W. 1965. Rapid spread of mottle and mild yellow edge viruses into hybrid strawberry selections. *Plant Disease Reporter* 49:284.
- Miller, P. W., and H. J. Jensen. 1965. Non-transmission of certain strawberry viruses by nematodes. *Plant Disease Reporter* 49: 509-511.
- Stretch, Allan W., and Raymond A. Cappellini. 1965. Changes in free amino acids and reducing sugars in highbush blueberry fruit infected with Glomerella cingulata. *Phytopath.* 55: 302-303.
- Stretch, Allan W. 1965. Red ringspot virus of cultivated highbush blueberry. *Proceedings of the 33rd Annual Blueberry Open House.* p. 3-4.

#### Culture and physiology

- Loomis, N. H. 1965. Further trials of grape rootstocks in Mississippi. *ASHS* 86: 326-328.
- Loomis, N. H., and B. O. Fry. 1965. Cold injury to muscadine grapes in Georgia and Mississippi. *Fruit Var. & Hort. Digest* 19(2): 35-36.
- Moore, J. N., and D. H. Scott. 1965. Effects of Gibberellic Acid and blossom removal on runner production of strawberry varieties. *ASHS* 87: 240-244.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Abdalla, Dennis A., and Harold J. Sefick. 1965. Influence of Nitrogen, Phosphorus, and Potassium levels on yield, petiole nutrient composition and juice quality of newly established Concord grapes in South Carolina. *ASHS* 87: 253. (S. C.)
- Bailey, John S., and Anthony W. Rossi. 1965. Effect of fall chilling, forcing temperature and day length on the growth and flowering of Catskill strawberry plants. *ASHS* 87: 245. (Mass.)
- Chaplin, C. E. 1965. Citation strawberry. *Kentucky Exp. Sta. Cir.* 605. (Ky.)
- Clore, W. J. 1965. Responses of Delaware grapes to Gibberellin. *ASHS* 87: 259. (Wash.)
- Haltvick, E. T., and Esther B. Struckmeyer. 1965. Blossom bud differentiation in red raspberry. *ASHS* 87: 234. (Wisc.)
- Kender, W. J. 1965. Some factors affecting the propagation of lowbush blueberries by softwood cuttings. *ASHS* 86: 301. (Me.)
- Sharples, G. C., F. E. Todd, S. E. McGregor, and R. L. Milne. 1965. The importance of insects in the pollination and fertilization of the Cardinal grape. *ASHS* 86: 321. (Ariz.)
- Way, R. D. 1965. Inheritance of the cutleaf character in elderberry. *ASHS* 86: 329. (N. Y.)
- Woodbridge, C. G., and W. J. Clore. 1965. A black leaf condition of Concord grapes in Washington. *ASHS* 86: 313. (Wash.)
- Zych, C. C. 1965. Incompatibility in crosses of red, black, and purple raspberries. *ASHS* 86: 307. (Ill.)
- Zych, C. C. 1965. Rooting of leaf-bud cuttings of Rubus neglectus inhibited by Gibberellin. *ASHS* 87: 238. (Ill.)

- Gill, H. S. and Dwight Powell. 1965. Differentiation in vitro of Pathogenic Races A-1, A-2, A-3, and A-4 of Phytophthora fragariae. Phytopathology 55(10), p. 1059. (Ill.)
- Millikan, D. F., S. R., Koirtyohann, and O. J. Upchurch. 1965. Effect of Varying Levels of Potassium and the Leaf Roll Virus Upon Mineral Content of Grape Leaf Tissue. Plant Disease Reporter 49, p. 36. (Mo.)
- Weber, J. Darrell, and J. M. Ogawa. 1965. The Mode of Action of 2,6-dichloro-4-nitroaniline in Rhizopus arrhizus. Phytopathology 55(2), pp. 159-165. (Calif.)
- Weber, D. J. and J. M. Ogawa. 1965. The Specificity of Proline in the Germination of Spores of Rhizopus arrhizus. Phytopathology 55(3), pp. 262-266. (Calif.)



CITRUS AND SUBTROPICAL FRUIT BREEDING AND GENETICS,  
DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Precise information is lacking about the interrelation between climatic factors and growth, cold hardiness and production; on the absorption processes and functions of various elements needed in growth and the effects of soil salinity, alkalinity and high water retention on growth; on the biochemistry of citrus metabolism and the effects of air pollutants on metabolism and growth; on various diseases and methods to control them. Currently used rootstocks do not induce enough cold hardiness in tops, are seriously affected by diseases and nematodes, are not tolerant enough to high soil alkalinity, salinity, and poor drainage and do not induce high-enough yields of high quality fruit. Present scion varieties generally lack cold hardiness, disease resistance, fruit quality, widespread season of maturity, and are unsuitable for both fresh market and processing.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term research program involving plant pathologists, physiologists, horticulturists, and plant breeders carrying on both basic and applied studies to enable growers of dates, avocados, and citrus to increase both production and quality. Citrus research is done at the Federal stations, Orlando, Florida; Weslaco, Texas; and Indio and Brawley, California; date breeding, disease and cultural research is done at Indio; and avocado disease and cultural research is done at Weslaco. Citrus hybridizations are made at Orlando and Indio but not at Weslaco and progenies are evaluated at all three locations; disease studies are carried on at all three Federal stations; basic physiology studies of cold hardiness are centered at Weslaco, with variety and hybrid progenies evaluated for cold hardiness at all three stations; rootstock evaluation on a field basis is centered in Florida but preliminary evaluation of hybrid rootstock progenies and certain species for cold hardiness, salt tolerance, and disease resistance is carried on at all three stations; basic nutrition is carried on principally in Florida but some work is also done in Texas and California. Climatology research is carried on in Florida, Texas, Arizona, and in several locations in California; the work in Arizona and California is in cooperation with the Agricultural Experiment Stations.

Air pollution studies are carried on in California under contract with the University of California at Riverside.

Nine 5-year P.L. 480 contracts are currently in effect with the: (1) Indian Agricultural Research Institute, New Delhi, citrus dieback in India; Department of Agriculture, University of Calcutta, Calcutta, India, (2) chemicals to increase fruit bud formation and overcome alternate bearing of mango, and (3) chemicals to improve methods of vegetative propagation, Israel Ministry of Agriculture, Volcani Institute of Agricultural Research,

Rehovot, (4) tolerance of evergreen fruit to lime and salinity, (5) new methods for assessing nutrient status in citrus trees and other plants, (6) the physiological basis of tolerance of horticultural crops to cold, drought, and water stress, and (7) develop a method for rapid propagation of superior date varieties, (8) Plant Virus Research Laboratory, Ministry of Agriculture, Cairo, Egypt, for citrus virus research, and (9) Instituto Biologica, Sao Paulo, Brazil, interference between strains of tristeza virus.

The Federal scientific effort devoted to research in this area totals 18.0 man years. Of this number 3.5 is devoted to breeding, 4.8 to diseases, 0.5 to variety evaluation, and 9.2 to culture.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 92 scientist man years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

1. Citrus. The Fairchild and Fortune, Indio, California, variety releases, have been released for commercial propagation in Texas. Two superior hybrids at Indio and 5 at Orlando are now undergoing extensive trials in Florida for pollination and rootstock requirements. Seedlings of salt-tolerant  $F_1$  hybrids are being grown for further tests to determine the value of the  $F_1$  hybrids as possible rootstocks.

##### B. Diseases

##### 1. Citrus

Virus diseases. At Elfers, Florida, indexing tests were set up to study the severity of the tristeza virus that is killing sweet orange trees on sour orange rootstock. Two California selections of Etrog citron proved to be rapid and sensitive indicators for exocortis virus under Florida conditions. Meyer lemons in Florida contain tristeza virus alone, tristeza plus tatter leaf virus, and tatter leaf virus alone. Tatter leaf is easily transmitted to different citrus hosts and to a number of herbaceous plants. Incontrovertible evidence was obtained that psorosis virus is transmitted through seeds of Carrizo citrange at a very high level. In California unbudded Cleopatra mandarin seedlings apparently carry a graft-transmissible disorder that resembles stubborn disease. Suitable indexing techniques for stubborn disease are still being sought. Leaf samples from stubborn-affected trees were lower in zinc content than those from trees free of stubborn.

United States sponsored P.L. 480 research in India on citrus dieback showed that dieback is due principally to tristeza virus which causes dieback



directly on Kagzi lime, probably on grapefruit, as well as on some other citrus kinds. It also causes dieback on sweet orange when brown on sour orange or lime rootstocks. Dieback of citrus in India is not related to Florida citrus blight. Similarly sponsored research in Egypt on citrus viruses show that stubborn disease, as well as the other common viruses affecting citrus, except tristeza, are present in North Africa. Research in Brazil on interference between strains of tristeza virus showed that with the virus sources used, those producing mild effects even on sensitive species like Calego lime, if thoroughly distributed in the test plants will afford good protection against subsequent inoculation with severe symptom producing virus sources.

## C. Culture and Physiology

### 1. Citrus

Rootstocks. The emphasis in rootstock improvement studies is shifting from horticultural evaluation of a wide range of genetic material to a closer look at selections of old-line rootstock varieties and to improvement through crossing of improved selections to combine two or more desirable traits into one variety.

Mineral nutrition. Broadcasting zinc sulfide, zinc sulfate, or zinc oxide to the soil was found to be a satisfactory method of supplying zinc to citrus trees. Leaf analyses indicate that a single application of zinc is effective for maintaining a steady supply of Zn for many years. Although anhydrous ammonia is a cheaper form of nitrogen than  $\text{NH}_4\text{NO}_3$  and has performed essentially equal to the other 2 sources, it is difficult and slower to apply and has no advantage over the others. When citric, malic, and tartaric acids are applied to a nutrient solution, it is doubtful if these ions are absorbed by orange seedlings.

In Israel, P.L. 480 research on new methods for assessing nutrient status in citrus and other plants, nitrate reductase activity was correlated with molybdenum levels and might be useful as an indicator of nutrient status.

Salt tolerance. In general, more chloride is accumulated in leaves from seedlings irrigated with water containing  $\text{CaCl}_2$  than in NaCl treatments. Some citrus varieties show the ability to exclude chloride, and the source of chloride salt influences the amount accumulated by each citrus variety. In tests of citrus rootstock varieties grown as scions, the chloride content of the leaves and their tolerance to chlorides were found to show little relation to the salt tolerance of the varieties when used as rootstocks for other varieties.

In Israel, P.L. 480 research on the physiological basis of the tolerance of evergreen fruit trees to lime and salinity showed the earlier reported differential protein synthesis of salt tolerant and salt sensitive citrus types was not associated with DNA-dependent polymerase (DDRP) but rather

with reputed, but yet unidentified, metabolic inhibitors of the protein synthesis. Reliably differential protein synthesis, whatever its cause, could be a useful biochemical measure of salinity tolerance.

Cold hardiness. Citrus varieties and hybrids were screened for cold hardiness in the field at Indio and Orlando following natural freezes during the winter of 1966. Other young hybrid seedlings from crosses involving mandarin parents were hardened and screened for cold hardiness at Weslaco using artificial techniques. Freezing inhibits CO<sub>2</sub> uptake by citrus leaves but it does not injure specific CO<sub>2</sub> fixation enzymes. Growth regulators used to induce dormancy inhibit citrus seed germination and seedling growth. Foliage sprays seriously distort leaves but not shoots. Translocation occurs as is indicated as being upward only.

Drought tolerance. Israeli P.L. 480 research on the physiological basis of the tolerance of horticultural crops to cold, drought, and water stresses showed that water status of plants is complex and that water deficiencies are multidirectional. Some evidence did show that the greater drought resistance of sweet lime as compared to rough lemon was associated with greater initial hydration.

Biochemistry. The low acidity of the Robinson, Lee, and Osceola tangerine hybrids in October is not due to a low acid content during summer growth by these varieties but due to a rapid loss of acids during ripening in October. The Dancy tangerine, by comparison, has approximately the same acid content (6.0%) in July as the hybrid tangerines but did not lose acidity as fast in the fall. The Succory acidless orange, on the other hand, contains only a very small amount of acid during its entire growth period. In Valencia oranges early spring temperatures are important in acid metabolism. In Texas the peak acid is reached in July; in Florida and Arizona, in August, and in Riverside, California, in October.

Climatology. New instrumentation at Foundation Farm greatly increased the frequency of sampling microclimate data and more than doubled the capacity. Grapefruit trees grown in artificial climates at Weslaco produced fruit with more peel color, higher brix and acids, and less lycopene content. The symptoms of heat injury to fruit leaves and stems of citrus were studied at Indio, preparatory to investigations of heat tolerance of citrus. The severity of the year's major freeze in Florida was offset by protection from either oil heaters or the solid fuel petroleum-base heaters but not by radiant-type coke heaters.

## 2. Dates

Fruit thinning. Size and grade of fruit of the Deglet Noor date thinned to bunches of 25 to 55 strands were not affected much by severity of thinning, but the most severely thinned trees yielded only 65% as much as the least severely thinned trees, thereby seriously reducing profits from the severely thinned trees.



Salt tolerance. The growth rate of date palms irrigated with solutions of chloride salts varying in concentration from 6 to 24 thousand parts per million decreased with increasing salt concentration of the irrigation water, but they were not severely injured probably because of the low absorption of salts by the palm roots.

### 3. Miscellaneous sub-tropical fruits.

Salt tolerance. In artificially salinized salt plot tests, papaya and carambola plants were found to be intolerant of salt, while Surinam cherries were relatively tolerant.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Breeding

- Nixon, R. W., and J. R. Furr. 1965. Problems and progress in date breeding. Date Growers' Inst. Rept. 42: 2-5.
- Olson, E. O., and B. Sleeth. 1965. Release to Texas growers of citrus budwood of virus-indexed selections of 11 varieties. Jour. Rio Grande Valley Hort. Soc. 19: 17-19.

### Diseases

- Carpenter, J. B., E. C. Calavan, and D. W. Christiansen. 1965. Occurrence of excessive seed abortion in citrus fruits affected with stubborn disease. Plt. Dis. Reprtr. 49: 668-672.
- Carpenter, J. B., and R. M. Allen. 1966. Occurrence of stubborn disease symptoms in trees propagated from normal-appearing and diseased 'Marsh' grapefruit. Phytopath. 56: 146. (Abstr.)
- Childs, J. F. L., J. L. Eichhorn, L. E. Kopp, and R. E. Johnson. 1965. Experimental evidence that cachexia and xyloporosis are caused by the same virus. Proc. 3rd Conf. Intern. Organization Citrus Virol. pp. 61-69. Edited by W. C. Price.
- Childs, J. F. L., R. E. Johnson, and J. L. Eichhorn. 1965. The question of seed transmission of cachexia-xyloporosis virus. Proc. 3d Conf. Intern. Organization Citrus Virol. pp. 90-94. Edited by W. C. Price.
- Childs, J. F. L., and R. E. Johnson. 1966. Preliminary report of seed transmission of psorosis virus. Plt. Dis. Reprtr. 50(2): 81-83.
- Feder, William A., and P. C. Hutchins. 1965. Differential susceptibility of selections of Poncirus trifoliata to attack by Tylenchulus semipenetrans. Phytopath. 55(10): 1058. (Abstr.)
- Feder, William A. 1965. Greenhouse studies of the effects of soil fumigation on the growth of burrowing nematode-tolerant rootstocks in old citrus soil. Cit. Ind. 46(11): 5-7, 11.
- Frolich, E. F., E. C. Calavan, J. B. Carpenter, D. W. Christiansen, and C. N. Roistacher. 1965. Differences in response of citron selections to exocortis virus infection. Proc. 3d Conf. Intern. Organization Citrus Virol. pp. 113-118. Edited by W. C. Price.

- Grant, T. J., A. A. Salibe, and C. Roessing. 1965. Tristeza tolerant rootstocks -- their behavior after twelve years in orchard. Proc. 3d Conf. Intern. Organization Citrus Virol. pp. 18-24. Edited by W. C. Price.
- Grant, T. J., and M. K. Corbett. 1965. Progress in citrus virology: Mechanical transmission. Proc. 3d Conf. Intern. Organization Citrus Virol. pp. 244-249. Edited by W. C. Price.
- Myers, Ronald F., William A. Feder, and Philip C. Hutchins. 1965. The rearing of Radopholus similis (Cobb) Thorne on grapefruit, okra, and alfalfa root callus tissues. Proc. Helm. Soc. Wash. 32(1): 94-95.
- Norman, P. A., and J. F. L. Childs. 1963. Attempted transmission of xyloporosis of citrus with insects. Proc. Fla. State Hort. Soc. 76: 48-50.
- Olson, E. O. 1965. Evidence that xyloporosis virus does not pass through seeds of Palestine sweet lime. Proc. 3d Conf. Intern. Organization Citrus Virol. pp. 86-89. Edited by W. C. Price.

### Culture and Physiology

- Cooper, W. C., R. H. Hilgeman, and G. K. Rasmussen. 1964. Diurnal and seasonal fluctuations of trunk growth of the Valencia orange as related to climate. Proc. Fla. State Hort. Soc. 77: 101-106.
- Cooper, W. C. 1965. Concepts of tree dormancy, cold hardiness, and freeze injury in relation to citrus. Jour. Rio Grande Valley Hort. Soc. 19: 40-47.
- Hewitt, A. A., and J. R. Furr. 1965. Uptake and loss of chloride from seedlings of selected citrus rootstock varieties. Proc. Amer. Soc. Hort. Sci. 86: 194-200.
- Hewitt, A. A., and J. R. Furr. 1965. Influence of salt source on the uptake of chlorides by selected citrus seedlings. Proc. Amer. Soc. Hort. Sci. 86: 201-204.
- Olson, E. O. 1965. Grafting citrus fruits to small potted seedlings. Jour. Rio Grande Valley Hort. Soc. 19: 20-24.
- Rasmussen, G. K., and W. H. Henry. 1964. Effects of arsenic on the growth of Pineapple orange seedlings in sand and solution nutrient cultures. Proc. Fla. State Hort. Soc. 77: 32-35.
- Smith, P. F. 1964. Changes in citrus fertilization over the past twenty-five years. Proc. Soil Sci. Found. 9: 25-27.
- Smith, P. F. 1964. Effect of potassium level and substrate lime on growth, fruit quality, and nutritional status of Valencia orange trees. Plant Anal. and Fert. Problems 4: 332-343.
- Smith, P. F., G. Hrcniar, and G. K. Scudder, Jr. 1964. Changes in soil composition during twenty years of differential phosphate application. Proc. Fla. State Hort. Soc. 77: 21-26.
- Yelenosky, George, R. O. Register, and C. J. Hearn. 1965. Recovery of citrus trees injured in the 1962 Florida freeze. Cit. Ind. 46(5): 5,6,16,17.
- Yelenosky, George. 1965. Problem of wind on effectiveness of heaters in a small-tree grove. Cit. Ind. 46(9): 5-10,16,18.



- Young, Roger. 1965. Microclimate temperatures of large and small citrus trees as affected by heat from LP gas heaters. Jour. Rio Grande Valley Hort. Soc. 19: 76-83.
- Young, Roger, and A. Peynado. 1965. Changes in cold hardiness and certain physiological factors of Redblush grapefruit seedlings as affected by exposure to artificial hardening temperatures. Proc. Amer. Soc. Hort. Sci. 86: 244-252.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Chapman, H. D., Joseph, H. and Rayner, D. S. 1965. Some effects of calcium deficiency on citrus. Proc. ASHS. Vol. 86, p. 183. (Calif.)
- Eaks, Irving L. 1965. Effect of chilling on the respiration of oranges and lemons. Proc. ASHS. Vol. 87, p. 181. (Calif.)
- Embleton, T. W., E. F. Wallihan, and G. E. Goodall. 1965. Effectiveness of Soil vs. Foliar Applied Zinc, and of Foliar Applied Manganese on California Lemons. Proc. ASHS. Vol. 86, p. 253. (Calif.)
- Ford, H. W. 1965. Bacterial metabolites that affect citrus root survival in soils subject to flooding. Proc. ASHS. Vol. 86, p. 205. (Fla.)
- Gerber, J. F. and F. Hashemi. 1965. The freezing point of citrus leaves. Proc. ASHS. Vol. 86, p. 220. (Fla.)
- Hartmann, H. T., and F. Loreti. 1965. Seasonal variation in rooting leafy olive cuttings under mist. Proc. ASHS. Vol. 87, p. 194. (Calif.)
- Jones, W. W. and C. B. Cree. 1965. Environmental factors related to fruiting of Washington Navel Oranges over a 38-Year Period. Proc. ASHS. Vol. 86, p. 267. (Calif.)
- Pieringer, A. P. and Edwards, G. J. 1965. Identification of Nucellar and Zygotic Citrus Seedlings by Infrared Spectroscopy. Proc. ASHS. Vol. 86, p. 226. (Fla.)
- Soost, R. K. 1965. Incompatibility Alleles in the Genus Citrus. Proc. ASHS. Vol. 87, p. 176. (Calif.)
- Thompson, Ray C., Lewis H. Stolzy, and Clifton O. Taylor. 1965. Effect of Soil, Suction, Relative Humidity and Temperature on Apparent Photosynthesis and Transpiration of Rough Lemon Citrus jambhiri. Proc. ASHS. Vol. 87, p. 168. (Calif.)
- Grant, T. J. and Corbett, M. K. 1965. Progress in Citrus Virology; Mechanical Transmission. Proc. 3rd Conf. Intern. Organ. Citrus Virol., Univ. of Fla. Press (Fla.)
- Trujillo, E. E. and R. B. Hine. 1965. The Role of Papaya Residue in Papaya Root Rot Caused by Pythium aphanidermatum and Phytophthora parasitica. Tech. Paper 744. (Hawaii)

TREE NUT BREEDING AND GENETICS, DISEASES,  
VARIETY EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Tree nut production in the United States is inadequate to meet the needs of the national consumption. Production of current varieties is not optimum and existing varieties are subject to diseases and frost damage to spray bloom. The nutritional requirements of nut trees are not completely known and the factors that induce biennial bearing are not understood. Diseases are often limiting factors and may even cause complete crop failure. Almonds are particularly subject to late frosts; later blooming varieties are feasible. Nut trees are known to have higher potassium requirements than the trees can absorb in heavy crop years but methods to increase absorption are not yet known. Current management research on tree spacing, dwarfing, rootstocks, and chemical fruit setters as well as more productive varieties have not yet achieved optimum production.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving breeders, plant pathologists, soil scientists, and horticulturists engaged in both basic studies and the application of known principles to the solution of growers' problems. Almond breeding research at Fresno, California, is cooperative with the California Experiment Station. Filbert breeding and cultural research at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Pecan variety evaluation, disease control, and cultural studies at Baton Rouge, Louisiana, and State College, Mississippi, are cooperative with the respective experiment stations. Disease control and orchard management at Albany, Georgia; disease control, orchard management and nutrition at Shreveport, Louisiana; variety evaluation, orchard management and breeding at Brownwood are at Federally operated stations. Research on walnut diseases and culture at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Breeding research and variety evaluation (chestnuts, filberts and hicans) is carried on at Beltsville, Maryland.

Grant supported research is being done as follows: absorption and translocation of potassium by pecan at the Georgia Agricultural Experiment Station; absorption and translocation of zinc by pecan at the Texas Agricultural Experiment Station; control of pistillate flower formation in pecan at the Alabama Agricultural Experiment Station; the mode of inheritance of pecan scab resistance at the Mississippi Agricultural Experiment Station; and the collection and evaluation of native pecan seedlings for horticultural characteristics at the Louisiana Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 12.9 scientist man-years. Of this number 2.7 is devoted to breeding; 3.4 to



diseases; 1.4 to variety evaluation; and 5.4 to culture.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 9 scientist man-years is devoted to this area of research.

### PROGRESS -- USDA AND COOPERATIVE PROGRAM

#### A. Breeding and Genetics

1. Almond. Planting the seed where the tree is to grow has given as good growth as planting a seedling, and saved man hours of labor and otherwise reduced cost.

2. Filbert. At Beltsville, Maryland, pollen from one filbert selection produced twice as many blank nuts as that from another when used on a standard variety. This may indicate that blank nut formation is caused by the kind of pollen that functions on each tree.

3. Pecan. One new variety, Mohawk, was released in 1965. This variety produces very large, thin-shelled nuts that ripen the earliest of the large-fruited sorts, thus enabling growers to receive fancy prices on the early market.

Results of a shelling and cracking test of 176 varieties and selections from the breeding program indicate that many of them are superior to commercially grown varieties. This is a stockpile of excellent material from which new varieties may be continuously developed.

4. Walnut. At Beltsville, two outstanding Carpathian (English) walnut seedlings producing nuts with 55 percent kernel were selected for propagation and testing.

#### B. Diseases

1. Walnut. The Howe walnut variety produced only .8 percent blight-infected nuts as compared to 12.7 percent for Franquette. This is the seventh consecutive year that Howe has shown excellent blight resistance.

#### 2. Pecan

Bunch disease. Thirty four of approximately sixty pecan varieties appear to be moderately to highly susceptible to bunch disease in initial tests.

Pecan scab. At Cordele, Georgia, 20% DuTer gave better control of pecan scab than Dodine (1/2-100) when 6 applications were made on Schley trees with a speed sprayer machine.

### C. Variety Evaluation

1. Walnut. Adams, Broadview and Schaeffer were the most blight-resistant of 14 varieties of Persian walnut under test at Corvallis, Oregon.
2. Pecan. At Shreveport, Louisiana, nuts of sixty varieties of pecans were rated on amount of fuzz adhering to the kernel as a part of variety evaluation. Preliminary studies indicate that amount of fuzz may be negatively correlated with percentage of fill of the nuts.

### D. Culture and Physiology

#### 1. Pecan

Mineral nutrition. Nitrate of potash applied to pecan trees in low concentrations (4 pounds per 100 gallons of water) increased the oil content of pecan kernels as much as higher concentrations previously used (8 pounds). This promises a means of improving nut quality at relatively low cost.

Dwarfing studies. In a test comparing six hickory species and six hican seedlings, results of one year indicate that one or more may act as a dwarfing interstock on pecan.

Six vigorous trees were grown from taproot cuttings of a single, 2-year old pecan seedling. With slight improvements, this new technique may make possible the production of clonal rootstocks.

#### 2. Filbert

Nutritional studies. Potassium increased the yield of filbert trees more than any other fertilizer element for the 4th consecutive year. Toxicity of the chlorine radical to filbert trees after spring application of muriate of potash was observed for the first time this year. Fall application is now recommended.

Spacing tests. Trees spaced 25 x 25 feet outyielded those 15 x 15 by .04 pounds of nuts per tree, but on a per acre basis the yield was 399 to 1023 pounds respectively. Growers throughout the area are using the 15 x 15 spacing in planting new orchards.

Pruning. In a rejuvenation pruning test on old trees, an 8 percent increase in yield was obtained the second year as compared to the unpruned plots.

Growth regulation study. Three applications of 2-4-5 T.P. caused the husks to remain green, and over half the nuts were retained on the trees at harvest time.



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

- McKay, J. W. 1964. Hican Seedlings, Their Origin and Value. Proc. Texas Pecan Growers Assoc. 43: 67-72.
- McKay, J. W. 1965. Progress in Black-Persian Walnut Breeding. Proc. Northern Nut Growers Assoc. 56: 76-80.
- Painter, John H. 1964. Data on Crack Test of Miscellaneous Filbert Varieties. Proc. Nut Growers' Soc. of Ore. and Wash. P. 39.
- Painter, John H. 1964. Chase Selections (Walnuts) 1964 Crack Test. Proc. Nut Growers' Soc. Ore. and Wash. p.56.

Diseases

- Cole, John R. 1965. Chemical Control of Pecan Scab in areas of High Rainfall. Proc. Southeastern Pecan Growers Assoc. 58: 60-71.
- Cole, John R. 1965. 1964 Spray Tests to Control Pecan Scab. Plant Disease Reporter 49: No. 8, 703-707.
- Cole, John R. 1965. Establishing a Pecan Orchard from Experience Gained after 40 Years Research on the Control of Scab and Other Pecan Diseases. Texas Pecan Growers Assoc. 43: 74-75.
- KenKnight, G. 1964. Research on bunch disease of pecan. Texas Pecan Growers Assoc. Proc. 43: 77-79.
- Miller, P. W. 1965. Progress Report on the Etiology of Blackline in Grafted Persian Walnuts. Plant Disease Reporter 49: 954.
- Miller, P. W., and I. C. MacSwan. 1965. Control of Filbert Blight in Oregon. Oregon Extension Cir. 645. 5 pp. Revised, August.

Varietal evaluation

- Painter, John H. 1964. Kernel Percentage and Size of 19 Walnut Varieties and Selections 1963 and 1964. Proc. Nut Growers' Soc. Ore. and Wash. pp. 54-55.

Culture and physiology

- Hunter, J. H. 1965. Effects of lime and zinc on the pH of soil, yield of pecans and zinc content of leaves. Proc. Southeastern Pecan Growers Assoc. 58: 6-12.
- McKay, J. W. 1965. The Increased Emphasis on USDA Pecan Research in the Southwest. Proc. Southeastern Pecan Growers Assoc. pp. 94-97.
- Painter, John H., and Roberto Paglietta. 1964. The Effect of Continuous Rains in January (normal period of maximum pollen dispersal) and Differential Mineral Applications on Set of Female Barcelona Filbert Flowers. Proc. Nut Growers' Soc. of Ore. and Wash. pp. 44-49.
- Painter, John H., and J. Thomas Raese. 1965. Mineral Content of Walnut (*Juglans regia* L.) Hulls, Shells, and Kernels. Proc. Amer. Soc. Hort. Sci. Vol. 87: 226-228.

PUBLICATIONS - STATE EXPERIMENT STATIONS

- Jaynes, R. A. 1965. Nurse Seed Grafts of Chestnut Species and Hybrids.  
Proc. ASHS. Vol. 86, p. 178. (Conn.)
- Kester, Dale E. 1965. Size, Shape, Weight Relationships in Almond Kernels.  
Proc. ASHS. Vol. 87, p. 204. (Calif.)
- Kester, Dale E. 1965. Inheritance of Time of Bloom in Certain Progenies  
of Almond. Proc. ASHS. Vol. 87, p. 214. (Calif.)
- Kester, D. E., C. J. Hansen, and C. Panetsos. 1965. Effect of Scion and  
Interstock Variety on Incompatibility of Almond on Marianna 2624 Root-  
stock. Proc. ASHS. Vol. 86, p. 169. (Calif.)



## SWEET CORN BREEDING

### Crops Research Division, ARS

Problem. Although the seed industry is providing most of the hybrid seed corn in use today, there is still a need for some basic and applied work in genetics, physiology, and pathology.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term research program on the breeding of sweet corn for resistance to certain diseases and insects as well as to enhance the quality of the corn. For 1965 this amounted to 2.3 scientist man-years.

### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.0 scientist man-years were devoted to sweet corn seeding in 1965.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### a. Breeding improved varieties.

Sweetcorn. Thirty-nine hybrids of the Southern Cooperative Sweet Corn Trials and 10 hybrids of NE-32 Sweet Corn Breeding Cooperative were tested in 1965. Also evaluated were 147 experimental hybrids developed at the U. S. Vegetable Breeding Laboratory and 14 Helminthosporium-resistant hybrids supplied by the Crookham Seed Company, with VBL inbred M822 as a common parent. Three of the Crookham Company hybrids were considered to be of commercial quality. Several VBL hybrids and two from the Southern Grain Insects Research Laboratory showed less damage from earworms than commercial hybrids.

The Ht gene was incorporated into selected earworm-resistant inbreds. Several new selections were made for earworm resistance in early maturing lines from an open-pollinated composite of sweet corn germ plasm. Two earworm-resistant corn lines, M6129 (St. Croix large kernel) and M6130 (St. Croix small kernel) were introduced from the Canary Islands. They showed a high level of resistance largely attributed to their tight, tough husks. M6130 also had a high frequency of ears with staminate tips which seem to interfere with normal feeding of the earworm.

The development of inbred lines carrying various combinations of the endosperm mutant genes, ae, du, su<sub>1</sub>, and wx was continued. Several hybrid combinations were made in order to make early evaluations of the effect of the mutant genes on carbohydrate content and quality maintenance.

b. Resistance to insects. The growth and molting frequency of earworm larvae (Heliothis zea) may be used as a measure of resistance in sweet corn. Periodic weight and head diameter measurements of the larvae growing on ears of sweet corn indicate this technique can be used.

An experiment was carried out to determine what the effect of time of infestation relative to silk emergence has on earworm penetration, development, and mortality in resistant sweet corn lines. It was concluded that earworm resistance is real and measurable, but that it diminishes with the maturity of the ear. Mortality rate of the larvae appear to be a good indicator of resistance only at the early infestation.

c. Quality improvement. The endosperm mutant genes, ae, du, and wx, improve sweet corn quality by increasing the sugar content at harvest and influencing the sugar retention during post harvest storage. Data were obtained by comparing Golden Security (su<sub>1</sub>), Illini Chief (sh<sub>2</sub>), and four experimental lines of the genotypes su<sub>1</sub>, wx, ae wx, and ae du wx. The ae wx combination had a high sugar content and a high retention ability. The mutant lines had less water-soluble polysaccharides than Golden Security, but they were higher than Illini Chief for all fractions except sugars.

#### PUBLICATIONS --USDA AND COOPERATIVE PROGRAM

##### Breeding and Genetics

- Beckett, J. B. 1966. Inheritance of partial male fertility in maize in the presence of Texas sterile cytoplasm. Crop Sci. 6:183-184.
- Boling, M. M., and Grogan, C. O. 1965. Gene action affecting host resistance to Fusarium ear rot of maize. Crop Sci. 5:305-307.
- Grogan, C. O., Sarvella, P., Sanford, J. O., and Jordon, H. V. 1965. Influence of cytoplasmic male sterility on dry matter accumulation in maize (Zea mays L.) Crop Sci. 5:365-367.
- Hallauer, A. R. 1965. Inheritance of flowering in maize. Genetics 52:129-137.
- Josephson, L. M., McCarty, I. E., and Kincer, H. C. 1965. Sweetcorn hybrids for home gardening. Tennessee Farm & Home Sci. Prog. Rptr. #53.



POTATO BREEDING AND GENETICS, DISEASES,  
AND VARIETY EVALUATION

Crops Research Division, ARS

Problem. The potato is grown in all 50 States and is planted or harvested every month of the year. Yield and eating and processing qualities vary greatly due to such extreme environmental differences between the many production areas. The rapid increase in potato processing--over 50 new products are made from the potato--has created a demand for more suitable varieties to solve many of the new quality factors that have appeared in these new products. Knowledge of genetic control of the enzymatic systems is needed for the development of potato varieties more suitable for processing. New methods of breeding, more interspecific hybridization, and more resistance to specific diseases to increase the yield and quality of the potato. Understanding the nature of disease and insect resistance and methods of control are needed to reduce crop losses and to lessen the need for chemical control.

USDA AND COOPERATIVE PROGRAM

The Department has a long-time program which was started in 1930 for the improvement of the potato by breeding methods, disease control, and cultural practices. Breeding, selecting, and testing of new varieties and seedlings for horticultural characters, storing, shipping, and culinary qualities and local adaptation are conducted cooperatively with the States at Presque Isle, Maine; Greeley, Colorado; Aberdeen, Idaho; Ames, Iowa; Baton Rouge, Louisiana; Ithaca, New York; Prosser, Washington; and Crystal City, Texas. In addition, testing of new seedlings is done at more than 25 additional locations in cooperation with State personnel.

Greenhouse crossing for production of true seed, for developing new varieties, and growing seedling tubers is done at Beltsville, Maryland; Aberdeen, Idaho; Baton Rouge, Louisiana; Prosser, Washington; and Greeley, Colorado. In cooperation with the Rockefeller Institute at Mexico City, seedlings from Beltsville are evaluated for field resistance to severe late blight conditions of the Toluca Valley; significantly resistant varieties have been released.

The world collection of Solanum stocks is maintained at Sturgeon Bay, Wisconsin, at the Inter-Regional Potato Introduction Station. The production and study of Solanum tuberosum diploids (half the normal chromosome number) is done at Madison, Wisconsin, along with interspecific hybridization of diploids. At Beltsville investigations of crossability among Solanum species and meiosis of species and species hybrids are being conducted.

In cooperation with the Division of Entomology a 3-year Federal Grant (CR-Ent-3) is currently in effect with Iowa State University at Ames, Iowa, to study the basic nature and significance of plant alkaloids in potato leafhopper host relations involved in plant resistance.

Two 5-year PL 480 projects are currently in effect: (1) with the Polish Academy of Science, Krakow, Poland, for study of environmental factors affecting quality of tubers used for seed; (2) with the Estacion de Mejora de la Patata, Vitoria, Spain, to develop techniques for eradicating, inactivating, or curing potato tubers from their tuber-borne viruses.

The Federal program devoted to research in this area adds up to 14.7 scientist man-years; 8.0 are assigned to breeding, 5.2 to diseases, 1.3 to culture, and 0.2 to variety evaluation.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 54 scientist man-years is devoted to this area of research.

#### PROGRESS--USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

1. Potato Tuber Greening. B5253-3, an early maturity type, is an example of a greening-resistant seedling which yielded 356 cwt. per acre of U.S. No. 1 tubers compared to 286 cwt. for Katahdin. It has shown resistance to verticillium wilt, scab, X and Y viruses, and leafroll.

2. Late Blight. Over 340 advance seedlings were screened for resistance to late blight at Toluca, Mexico, in cooperation with the Rockefeller Foundation, and at Presque Isle, Maine, in cooperation with the Maine Agricultural Experiment Station. Two selections, B5716-5 and B5755, showed excellent field resistance to late blight in both areas. B5716-5 yielded 374 cwt. per acre of U.S. No. 1 tubers and showed resistance to verticillium wilt, scab, viruses X and Y and tuber greening. B5755-7 had lower yielding ability but it was rated high in its resistance to verticillium wilt and scab.

3. Potato Cytogenetics. In cooperation with the Wisconsin Experiment Station problems related to ploidy and crossability in haploids of S. tuberosum L., and the tuber bearing Solanum species were continued. From 730 haploids derived from 36 varieties or seedling parents, 60 percent of those flowering were used successfully as female parents and 34 percent shed sufficient pollen to be tested for male fertility, and of these 5 percent were used successfully as male parents. A study to develop and to evaluate the effects of inbreeding in diploids and tuber-bearing Solanum species and two tuberosum haploids was initiated. The inbreeding of the S<sub>1</sub> families



were evaluated and the most vigorous family lines were selected to provide a wider genetic base for the search for lines that will survive from continued inbreeding. Plants in the S<sub>2</sub> and S<sub>3</sub> families were weak, and flowering and tuberization were severely reduced. Families resulting from crosses among the diploid clones and the same crosses between their doubled counterparts were studied again in 1965. The tetraploids had more stems, were taller after 4 weeks of growth, flowered later, and had more tubers over 1.5 inches in diameter but there was no difference between diploid and tetraploid families in total tuber number or yield. Cytological study of 40 diploid interspecific hybrids grown at Beltsville, showed normal chromosome behavior during meiosis in the pollen mother cells. F<sub>2</sub> seed was obtained from sib-mating in 25 of the diploid hybrids. When used as females, 19 were successfully backcrossed to the female parent species and 22 the male parent species.

4. Ring Rot. In cooperation with the Maine Agricultural Experiment Station, 19 out of 344 seedlings tested for ring rot resistance were found free of tuber symptoms. Seedlings B4829-7, B5000-18, and B5052-7, included in the resistant group are now on increase for commercial evaluation.

5. Leafroll. In cooperation with the Maine Agricultural Experiment Station only 5 seedlings out of 344 tested remained completely free of leafroll infection in 1965. The early-maturing seedling B5253-31 is an example of one that yielded 356 cwt. per acre and showed resistance to verticillium wilt, scab, virus X and Y.

6. Varieties for the South. In cooperation with Louisiana Agricultural Experiment Station, seedlings TL8322, TL8117, and TL7627 have performed well in many trials and are being increased for commercial evaluation.

7. Varieties for the West. In cooperation with the Agricultural Experiment Stations of Colorado and Wyoming, seedlings and varieties were screened for resistance to scab, verticillium wilt, early blight, and rhizoctonia. Resistance to all these diseases were isolated. Tolerance to rhizoctonia lesion formations in the stems were observed between known varieties--a step forward in this study. Tuber resistance to early blight was well demonstrated. It appears that foliage resistance and tuber resistance may be independently inherited.

In cooperation with the Idaho Agricultural Experiment Station, 330 seedlings from 19,000 grown in single hills were saved for further evaluation. Seedling A60120-1, an oblong russet with resistance to scab and verticillium wilt, outyielded Russet Burbank for the second year with 251 cwt. per acre of U.S. No. 1 tubers compared to 200 cwt. for Russet Burbank.

In cooperation with the Washington Agricultural Experiment Station, 109 out of 35,000 seedlings grown in 1965 were selected for increase and evaluation in 1966. Seedling 168-3 appears to be the most promising russet-

skinned type selected to date. It has resistance to scab, verticillium wilt and late blight and rates high in solids (1.114 in 1965) and chipping quality.

In cooperation with the Texas Agricultural Experiment Station, yield and observational trials were conducted at several locations. Seedlings B5066-3 and B5088-7 with yields of 327 and 301 cwt. per acre compared to 231 cwt. for Kennebec were the two outstanding seedlings of 11 indicated for advance increase and testing in 1966.

8. New Releases. Chieftain was released cooperatively with the Iowa Agricultural Experiment Station. It has shiny medium red-skinned tubers and moderate resistance to scab and rugose mosaic. It has medium maturity and is well adapted to production in Iowa, Minnesota, and North Dakota.

9. Outstanding Seedlings. Seedling B5141-6 is outstanding for its high solids content and chipping qualities when grown in many northern and southern States. Apparently the sugar content at Normal storage temperatures (40° F.) is accumulated slowly. Satisfactory chips have been made repeatedly from tubers stored at 40° F. Seedling B5036-40 possesses yielding and processing qualities combined with resistance to several diseases and the golden nematode and wide adaptation. Both selections are being increased for further commercial evaluation.

10. Potato Introductions. In cooperation with Plant Introduction Investigations of the New Crops Research Branch, 99 new stocks were received in 1965 from 11 countries (Afghanistan, Australia, Bolivia, Chile, Ecuador, Japan, Mexico, Peru, Sweden, USSR, and West Germany). Shipments to 17 States and 12 countries included 1,449 seed and 773 tuber samples of species, and 89 seed and 830 tuber samples of germ plasm involving introductions developed by the cooperative USDA-Wisconsin Genetics and Cytogenetics Project.

11. Quality Evaluation of Seedlings and Varieties. Approximately 149 seedlings and varieties and 171 advance selections were compared for yielding ability, U.S. No. 1 grade percentages, specific gravity, and chipping quality. Yields varied from 477 cwt. of U.S. No. 1 tubers to 143 cwt. Specific gravity readings ranged from 1.089 to 1.051. From the 171 advance selections 55 were replanted for increase because of their multiple disease resistance, yielding ability, and tuber qualities or combinations of all these factors. B5463-15 is a good example of an early-maturing white-fleshed selection that yielded 257 cwt. of U.S. No. 1 tubers per acre, has good chipping and processing qualities, and is resistant to golden nematode. These newer selections will be evaluated again in 1966.

In cooperation with Campbell Soup Company in 1965, 24 seedlings and varieties and 32 advance selections were grown at four locations (Maine, New Jersey, Ohio, and Wisconsin). This material plus 320 additional



selections grown in Maine were evaluated for yield, specific gravity, french frying, sloughing, and translucency before and after storage at various temperatures. B4829-7, B5000-18, and B5036-40 and B5066-3 which were retested in 1965 and several newer selections showed excellent processing qualities and will be increased again in 1966. Additional trials at 3 locations in Texas indicated the above selections plus B5141-6, B5088-7, B5458-3, B5461-4, and B5463-1 were also exceptional in yield and processing qualities when grown in Texas.

## B. Diseases

1. Potato Spindle Tuber Virus. Seed Transmission--The potato spindle tuber virus (PSTV) was recovered from two potato plants grown from true seed. One plant originated in a 39-plant progeny of PSTV-infected Merrimack selfed and the other in a 30-plant progeny of PSTV-infected Katahdin selfed. Over 350 individual seedling plants from 28 crosses with four varieties were tested. Combinations in which either the male parent, the female parent, or both parents were infected with PSTV, were tested. PSTV infection was determined by indexing on Rutgers tomato plants. Both the first seedling generation and the subsequent first tuber generation plants were indexed. This test is not conclusive proof of PSTV seed transmission but does indicate a reasonable possibility of such transmission. A large-scale test is needed to confirm this finding. Even .1% seed transmission would be of great importance to potato breeding programs. No other potato virus is known to be transmitted through true seed.

Tuber Indexing of Advanced Selections. About 620 plants from tubers of 40 advanced potato selections were indexed for the presence of PSTV on Rutgers tomato and for potato virus X on Gomphrena globosa. Results from indexing 450 plants the previous year indicated that only one tuber infected with PSTV was not detected by the tomato test. The indexed tubers form the seed source for further field propagation of these selections.

Potato Spindle Tuber Virus from Nebraska. The potato spindle tuber virus (PSTV) culture obtained from Nebraska and reported to be a strain of potato virus X, was found to be a mixture of potato viruses X, S, M, and PSTV. When viruses X, M, and S were eliminated by passage through differential hosts the PSTV component remained and was free of virus X.

2. Control of Virus Y Spread. The third year of testing oil-water emulsions for suppression of virus Y spread by aphids, in cooperation with the Entomology Research Division, resulted in about 60% control. This means of control may have practical value in conjunction with other control practices but is not sufficiently effective to be used alone for production of certified seed.

3. Multigenic Field Resistance to Late Blight. In cooperation with M. E. Gallegly of West Virginia University and J. S. Niederhauser of the

Rockefeller Foundation in Mexico, tests for multigenic field resistance in potatoes were conducted in Maine, West Virginia, and Mexico. Advanced selections, parents, and clones known to be resistant to late blight were tested in these three locations. Due to extreme drought the West Virginia test was eliminated, but results were obtained from Maine and Mexico. Fifteen clones of 368 not previously tested were found to have moderate resistance in Mexico and excellent resistance in Maine. Six of these clones were selected as parents for further breeding work. A few clones that were moderately resistant in Mexico were quite susceptible in Maine. This emphasized the need for testing facilities in the northeast potato region where late blight occurs.

## PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

### Breeding

- Akeley, R. V., W. V. Audia, and P. H. Heinze. 1965. Some newer potato varieties and their chipping qualities. Proc. Production and Technical Div. Meetings, Potato Chip Institute, Internatl. pp. 9-10 (MQ2).
- Akeley, R. V., R. W. Buck, F. I. Lauer, J. C. Miller, S. J. Peloquin, and D. A. Young, (Chairman). 1966. Report of the potato varieties, breeding cytogenetics committee. Potato Handbook. 11: 71-75.
- Buck, R. W. 1966. Review of the literature on cytology and interspecific hybridization in the tuber-bearing Solanums (1960-1964). Potato Handbook. 11:62-68.
- Cunningham, C. E., R. V. Akeley, T. E. Snyder. 1965. Evaluation of potato varieties for the sloughing and translucency of dice following freezing during processing. Fourteenth National Potato Utilization Conference Report. ARS: 74-30, p. 38.
- Miller, J. C., and J. F. Fontenot. 1965. Methods and techniques for breeding the Irish potato. Amer. Potato Jour. 42: 174-176.
- Murphy, H. J., M. J. Goven, R. V. Akeley, P. T. Blood, W. R. Kelley, and R. Jensen. 1966. Maine-New Hampshire-Vermont potato variety trials for 1965. Misc. Pub. 673, Maine Agricultural Experiment Station.

### Diseases

- Hoyman, W. G., and E. Dingman. 1965. Effect of certain systemic insecticides on the incidence of Verticillium wilt and the yield of Russet Burbank potato. Amer. Potato Jour. 42: 195-200.

### Variety Evaluation

- Stevenson, F. J., R. V. Akeley, G. Newton, and D. Isleib. 1965. Monona: A new variety of potato, distinctive for excellent chip color after numerous storage treatments. Amer. Potato Jour. 42: 253-255.



PUBLICATIONS--STATE EXPERIMENT STATIONS

- Burrell, R. G., C. W. Clayton, M. E. Gallegly, and V. G. Lilly. 1966. Factors affecting the antigenicity of the mycelium of three species of Phytophthora. Phytopathology 56: 422-426. (W. Va.)
- Carpenter, P. N. and J. J. Murphy. 1965. Effects of accumulated fertilizer nutrients in a Maine soil upon the yield, quality, and nutrient content of potato plants. Maine Exp. Sta. Bull. 634. (Me.)
- Doney, D. L., R. L. Plaisted, and L. C. Peterson. 1965. Genotypic competition in progeny performance evaluation of potatoes. Crop Science 5(5) pp. 433-435. (N.Y.)
- Hart, T. G. and Ora Smith. 1965. The effects of levels and sources of potassium on the absorption of phosphorus by potato plants. Amer. Potato Jour. 42. (N.Y.)
- Lauer, F. I., R. Millin, and A. W. Blomquist. 1965. Potato seed germination as influenced by food blender injury, gibberellic acid, thivam, and fermentation. Amer. Potato Jour. 42: 71-75 (Minn.)
- Murphy, E. F., and F. E. Manzer. 1965. Potato flavor quality as affected by two fungicides. Amer. Potato Jour. 42: 48-49 (Me.)
- Murphy, H. J., and M. J. Goven. 1965. Effect of source of potash on yield, specific gravity, and surface russetting of the Russet Burbank in Maine. Amer. Potato Jour. Vol. 42 No. 7. (Me.)
- Peloquin, S. J., R. W. Hougas, and A. C. Gabert. 1965. Haploidy as a new approach to the cytogenetics and breeding of Solanum tuberosum. Heredity 20(5): 21-28. (Wisc.)
- Ross, R. W., and P. R. Rowe. 1965. Inventory of tuber-bearing Solanum species. Wisc. Agr. Exp. Sta. Bull. 533. (Wisc.)
- Ross, R. W., and P. R. Rowe. 1965. Frost resistance among the Solanum species in the IR-1 collection. Amer. Potato Jour. 42: 177-185. (Wisc.)
- Timm, H., and V. H. Schweers. 1965. Effect of temperature and seed treatment on respiration, sprouting, and decay of seed potatoes. Proc. ASHS. Vol. 86, p. 502. (Calif.)
- Wurster, R. T., and Ova Smith. 1965. Translocation of iron-59 in the potato plant. Amer. Potato Jour. 42. (N.Y.)
- Yeh, B. P., and S. J. Peloquin. 1965. Pachytene chromosomes of the potato (Solanum tuberosum Group Andigena). Amer. Jour. Bot. 52: 1014-1020. (Wisc.)
- Orlob, G. B. 1965. Effects of photosensitizing dyes on purified tobacco mosaic virus. Phytopathology 55: 1070 (S.D.)
- Weinhold, A. R. and Tully Bowman. 1965. Influence of substrate on activity of a bacterium antagonistic to Streptomyces scabies. Phytopathology 55: 126 (Calif.)

SWEETPOTATO BREEDING AND GENETICS,  
DISEASES, AND VARIETY EVALUATION

Crops Research Division, ARS

Problem. The acreage and per capita consumption of sweetpotatoes are now only about one-fifth what they were in the early 1930's, but have leveled off and stabilized somewhat due to reductions in expensive labor costs and to development and availability of a number of processed sweetpotato products more convenient to the needs of the modern housewife. Costs of sweetpotatoes to the consumer still are high compared with other commodities. Larger yields per acre are needed. Losses from serious bacterial, fungal, and virus diseases continue to be high so continued research on diseases is needed. New varieties combining superior, productive, horticultural, and quality characteristics with resistance to serious diseases and suited to mechanized cultural and handling procedures are needed for both the fresh market and for processing.

USDA AND COOPERATIVE PROGRAM

The breeding program, utilizing selected parent stocks, has been continued at Beltsville in the search for better disease-resistant types suited to fresh market and processing requirements. The inherent and performance characteristics considered in the program are root shape and uniformity; appearance; size; set; skin and flesh colors; overall yielding capacity and yields of desired grade classes for specific uses, baking and processing quality properties, storability, propagative characteristics, general plant vigor, and growth habits; adaptability to mechanized culture and handling procedures; and resistance to diseases and pests. Pathological studies are conducted and techniques developed for eliminating virus infections. Investigators in 20 States cooperate in the sweetpotato improvement program. Coordination of the overall cooperative improvement effort is handled at Beltsville, Md.

A program to develop better sweetpotato breeding parent lines is conducted at Tifton, Georgia, by Federal workers in cooperation with the Georgia Coastal Plain Experiment Station. The program includes quantitative and qualitative genetic studies and cytogenetic studies of other Ipomoea species.

The Federal effort devoted to research in this area totals 4.0 scientist man-years annually. Of this total, 2.8 are devoted to breeding and genetics and 1.2 to diseases.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 26 scientist man-years is devoted to this area of research.



## PROGRESS--USDA AND COOPERATIVE PROGRAMS

### A. Breeding, Genetics, and Varietal Evaluation

1. Breeding and Cytogenetic Studies. Intercrossing has been continued at Tifton, Ga., among 12 introductions and seedling selections with known reactions to wilt, black rot, internal cork, and to nematodes. Greenhouse and field screening of resulting seedlings has progressed in the search for new parental stocks with multiple disease and nematode resistance, good flowering, and regular meiotic characteristics. Fifteen out of 57 seedlings screened in an inoculated root-knot nematode test field rated resistant, 36 were intermediate, and 6 were susceptible to root knot.

Viable seeds were obtained during the year from interspecific crosses among 15 wild Ipomoea species in the Tifton collection.

Chromosome complements of various Genome A 30-chromosome plants have been doubled by colchicine treatment. Plants of the resulting 60-chromosome types were subsequently crossed with 30-chromosome plants and 30 seeds were obtained. It is presumed some of the seedlings obtained from these seeds will have 45 chromosomes. Upon further treatment with colchicine, some 90-chromosome Genome A types may be found that can then be crossed to I. batatas.

2. Applied Breeding. Eighteen selected parents were used in the breeding program at Beltsville. Of 4,900 new seedlings screened during the year, 45 possess color, yield, and edible quality properties justifying further performance evaluations.

3. Regional Tests of Advanced Selections. C-56-35 and L-9-89 continued to exhibit satisfactory properties and performance in the "Replicated Trials" conducted by USDA and 17 State stations. Julian (L-8-3) set roots heavily and gave high yields of canning sizes and moderate yields of market-size stock. Roots of this variety tended to be somewhat long, and sprout-plant production was low. Cracking and poor sprout production also occurred in Gem, an otherwise outstanding variety. L-0-132 was the most promising of the seven "Observational Test" selections.

4. New Variety Release. USDA HM-122, a moderately high-yielding selection for fresh market use, has been named HOPI. This was released jointly by USDA and the New Mexico Station primarily for growing under irrigation in eastern New Mexico and similar southwestern growing areas.

5. Enzymatic Darkening in Selections. Darkening ratings were made on 9 introductions, 69 Beltsville seedlings, and 4 named varieties. Very little enzymatic discoloration occurred in the introductions 286629 (from New Zealand) and 296116 (from Philippines) but, except for productiveness and some wilt resistance, neither of these appeared promising in other respects. Notably little flesh discoloration was observed in eight 1964 Beltsville seedlings, six of which are to be included in replicated field trials in 1966.

## B. Diseases

1. Fusarium Wilt. Refrigerator drying and storing in petri plates was shown to be effective in maintaining virulence for one year in 34 stem-section cultures of the wilt fungus.
2. Russet Crack. Necrotic leaf spot symptoms of the heat-stable russet crack virus can remain masked when the internal cork syndrome is present. All Jersey-type varieties usually exhibit both root and foliage lesion symptoms of this disease. Foliage symptoms have remained masked in all other crack-susceptible varieties tested to date at Beltsville. A survey made in October 1965 on the incidence of russet crack in sweetpotato-producing States, showed that this disease is widespread in New Jersey, Maryland, and Virginia. So far, no effective method has been devised for the control of this disease.

## PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

### Breeding, Genetics, and Variety Evaluation

- Jones, Alfred. 1965. Cytological observations and fertility measurements of sweetpotato (Ipomoea batatas (L.) Lam.). Amer. Soc. Hort. Sci. Proc. 86: 527-537.
- Jones, Alfred. 1965. A proposed breeding procedure for sweetpotato. Crop Science 5(2): 191-192.
- Jones, Alfred and M. T. Deonier. 1965. Interspecific crosses among Ipomoea lacunosa L., I. ramoni Choisy, I. trichocarpa Ell., and I. triloba L. Bot. Gaz. 126(3): 226-232.

### Diseases

- Hildebrand, E. M. 1965. Susceptibility of sweetpotato varieties to yellow dwarf. Plant Dis. Reptr. 49(5): 425-428.
- Hildebrand, E. M. 1964. Adaptation of the abutilon whitefly for laboratory use. Plant Dis. Reptr. 49(5): 429-432.

## PUBLICATIONS--STATE EXPERIMENT STATIONS

- Barry, J. R. and D. R. Paterson. 1965. Some effects of a chilling temperature on IAA inactivation by sweet potato root tissue. Proc. ASHS. Vol. 86, p. 542 (Tex.)
- Hernandez, Travis P., Teme P. Hernandez, Roysell J. Constantin, and Julian C. Miller. 1965. Inheritance of and method of rating flesh color in Ipomoea batatas. Proc. ASHS. Vol. 87, p. 387 (La.)
- Robbins, M. L. and W. L. Ogle. 1965. The influence of calcium nutrition and duration of holding time on reaction of sweet potato sprouts to fusarium wilt. Proc. ASHS. Vol. 86, p. 523 (S.C.)



PUBLICATIONS--STATE EXPERIMENT STATIONS (Continued)

- Fisher, K. D. 1965. Hydrolytic enzyme and toxin production by sweetpotato Fusaria. Phytopathology 55: 396-398 (N.C.)
- Martin, W. J. 1965. Elimination of the black rot fungus from diseased sweetpotato roots by a dry heat treatment. Phytopathology 55: 1066-1067 (La.)

ONION, CARROT, AND OTHER ROOT AND BULB CROP BREEDING  
AND GENETICS, DISEASES, AND VARIETY EVALUATION

Crops Research Division, ARS

Problem. The production of carrots, onions, garlic, shallots, leek, chives and related crops is fairly well stabilized in highly specialized areas. Varieties and hybrids are usually limited to specific regions of adaptation. Breeding is necessary to incorporate disease and insect resistance, desirable horticultural characters and genetic markers into varieties suitable for specific purposes. Serious hybrid onion seed production problems still exist. In carrots, the production of hybrid seed is under way, but the genetic mechanisms controlling male sterility are still not understood. Continued research on the pathology, physiology, genetics, and cytology of these crops and studies of the fundamental nature of male sterility in plants are needed to aid the improvement of varieties and hybrids.

USDA AND COOPERATIVE PROGRAM

The primary objectives have been to develop new and improved breeding lines, varieties, and hybrids of onions and carrots that are disease- and insect-resistant, more productive, of better quality, and suitable for special uses. Work was done by Federal personnel at Beltsville, Maryland; Greeley, Colorado; and Parma, Idaho, working cooperatively with many State Experiment Stations and private seed and food-processing companies. The major research at Beltsville has been on genetic control of diseases and insects and on the nature and origin of cytoplasmic male sterility. Useful germ plasm has come from cultivated species and related wild species. The personnel at Parma worked mostly in the areas of cytology and genetics. Plant breeding, principally the development or improvement of hybrids using cytoplasmic male sterility, was done cooperatively at Madison, Wisconsin; Davis, California; and Ithaca, New York.

The domestic research program is supplemented by PL 480 projects on onion downy mildew and root greening in carrots, Poland; cytoplasmic male sterility and the development of carotene bodies in the carrot root, Israel.

The Federal scientific effort devoted to research in this area totaled 2.2 scientist man-years, divided as follows; 2.0, breeding and genetics, 0.2 diseases.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 22 scientist man-years is devoted to this area of research.



PROGRESS -- USDA COOPERATIVE PROGRAMS

A. Breeding and Genetics

1. Amphidiploid onions. Fertile clones of colchicine-treated sterile inter-specific hybrids (cepa x galanthum, cepa x pskemense) were confirmed to be tetraploid. Approximately 700 bulbs grown from open-pollinated tetraploid B 9166 A (Yellow Ebenezer) x A. pskemense resembled the  $F_1$  in having red scales. The absence of yellow segregates is evidence of typical allotetraploid chromosome pairing.
2. Linkage testers in onions. A search for trisomic plants to develop linkage tester lines was made among the offspring of open-pollinated triploids ( $3n = 24$ ), essentially  $3n \times 2n$  crosses. Of the 172 offspring examined, 39% were trisomics.
3. Soluble solids in onions. An estimate of 74% for heritability of soluble solids in a population of White Sweet Spanish was obtained from the regression of maternal half-sib family mean on seed parent. Readings ranged from 5.4 to 11.0% in the original population.
4. Annual flowering in onions. Although information about the environmental conditions which stimulate annual flowering is scarce, it is generally believed that low temperature during seedling growth increases the number of bolters in the Sweet Spanish late-summer bulb crop. Obtaining genetic information from field plantings is complicated by year-to-year variations in stimulative conditions. However, inbred lines which differ greatly in annual flowering tendencies were developed at Parma, Idaho, from field selections within the Langen strain of Yellow Sweet Spanish. In 1964, 128  $S_2$  lines ranged from 0 to 71% annual flowering. In 1965 a mass increase of one of the "easiest" flowering inbreds bolted 76%.
5. Greening of carrot roots. The vertical extent of greening measured from the root crown in a replicated planting of two lines selected for and against greening was varied deliberately by hilling up some plots to reduce greening and partially uncovering others to increase greening. Both lines reacted in the same way to the environmental manipulations. Correlations were high between greening measured externally and greening measured internally after longitudinal bisection; low between external greening and root size; and negligible between internal greening and size. The length/diameter ratio, a rough index of shape was negatively correlated with root weight and diameter, but practically independent of root length.
6. Breeding. Resistant onion selections for increase were made of B 1410C, TEG 951 C, and YB 986 A and B from the Texas pink root nursery, B 2190 and Ia 2997 from the Oregon pink root nursery, and B 3343 from thrips screening in Ohio. Hybrid onions Ia 2997 x P 54-306 and (B 5546 x B 2108) x Ia 2997 ranked high in yield and storage trials at Greeley, Colorado. Carrot line B62-1771 derived from Red Cored Danvers showed excellent quality in Maryland and is being increased for wider testing and possible release.

B. Diseases

1. Onion mildew. In Poland, fungus mycelia hibernating in onion bulbs is the principle source of primary infection. Six new host plants were found: Allium altaicum, A. obliquum, A. coeruleum, A. moschatum, A. beesianum, and A. strictum. (PL 480 E21-CR-17)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None.

PUBLICATIONS -- STATE EXPERIMENT STATIONS

Bienz, D. R. 1965. Carrot splitting and second growth in Central Washington as influenced by spacing, time of sidedressing, and other cultural practices. Proc. Am. Soc. for Hort. Sci. 86: 406. (Wash.)

Bliss, F. A., and W. H. Gabelman. 1965. Inheritance of male sterility in beets, Beta vulgaris L. Crop Science 5(5): 403-406. (Wisc.)

Bradley, G., and D. Smittle. 1965. Carrot quality as affected by variety, planting, and harvest dates. Proc. Am. Soc. for Hort. Sci. 86: 397. (Ark.)

Engle, R. L., W. H. Gabelman, and R. R. Romanowski, Jr. 1965. Tipburn, an ozone incited response in onion, Allium cepa. Proc. Am. Soc. for Hort. Sci. 86: 468. (Wisc.)

Lorbeer, J. W., and K. W. Stone. 1965. Reaction of onion to Fusarium basal rot. Plant Dis. Reprtr 49: 522-526. (N.Y.)



PEA AND BEAN BREEDING AND GENETICS, DISEASES,  
VARIETY EVALUATION AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Diseases are the major obstacle to increased production of beans and peas, and therefore, the development of multiple-resistant varieties is being given top priority. Newly developed varieties also must be widely adapted, productive, of high quality, and suitable for mechanical harvesting. Biological control of pests through breeding and other means are preferred to chemical methods when feasible. Efforts to develop stem anthracnose and nematode resistance in lima beans must continue. With the acreage increase of southern peas in the South, additional information on disease control of this crop and on dry peas and lentils in the West is needed.

USDA AND COOPERATIVE PROGRAM

At Beltsville, Maryland, studies on breeding techniques and on the inheritance of resistance to certain diseases of snap beans and lima beans are conducted. Aid in the evaluation of breeding materials in the several field locations is managed from here.

At Prosser, Washington (cooperative with the Washington Agricultural Experiment Station), breeding studies are conducted on dry beans for the West and on snap beans for the entire country. Major objectives are resistance to several mosaic diseases, curly top, and fusarium root rot. Inheritance of resistance to curly top in both dry and snap beans is also being studied. Breeding of disease-resistant peas is conducted at Prosser and on southern peas at Tifton, Georgia (cooperative with the Georgia Coastal Plain Experiment Station). The objective on peas is the development of disease-resistant breeding stocks for variety development by commercial breeders of seed and processing companies. At Pullman, Washington, the development of superior lentil and dry pea varieties is conducted (cooperative with the Washington Agricultural Experiment Station).

At East Lansing, Michigan, breeding and selection of disease-resistant pea bean, Red Kidney, and Cranberry types chiefly for Michigan and New York are conducted (cooperative with the Michigan Agricultural Experiment Station).

At Charleston, South Carolina, disease-resistant snap beans for market and processing are bred for adaptability to the Southeast.

At Beltsville, Maryland, pathologic studies on virus, fungus, and bacterial diseases and development of control measures are conducted on snap, dry and lima beans and peas. Similar studies on dry beans are conducted at East Lansing, Michigan, and on virus diseases of peas in the Northwest at Corvallis, Oregon (cooperative with the Oregon Agricultural Experiment Station). Work, mainly on fungus diseases of peas, is conducted at Prosser, Washington, and diseases of southern peas at Tifton, Georgia. The relationship of nematodes to root rot infection of beans is also investigated at Prosser, Washington. Studies on diseases of dry peas and lentils are made at Pullman, Washington. In Iran and India, work has been undertaken on the USDA/AID Regional Pulse Improvement Project. A cooperative project with AID on diseases of dry beans is conducted in El Salvador, Central America.

The Federal scientific effort devoted to research in this area totals 17 scientist man-years. Of this number 7.5 are devoted to breeding and genetics, 8.0 to disease, and 1.5 to variety evaluation.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 49 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

##### 1. Dry Beans

a. Disease resistance. In Washington two new Red Mexican bean varieties, "Bigbend" and "Coulee," were released to western bean growers. Both resist the principal seedborne viruses and curly top. They are earlier maturing and shorter vined and less subject to Sclerotinia wilt than the present commercial varieties. Progress continued in the selection of fusarium- and multiple virus-resistant dry beans in four varietal types. Many selections were made among lines with twice the yielding ability of root rot-susceptible commercial varieties when grown in Fusarium-infested soil.

b. Virus-, rust-, and angular leaf spot-resistant types for El Salvador, C.A. From crosses made in 1964 between Porillo No. 1, an El Salvador type, and several American black- and red-seeded varieties, a number of outstanding, high-yielding, market-acceptable, black-seeded, virus- and rust-resistant lines in the F<sub>6</sub> generation were selected; and one is being increased for release to growers. Other types showing resistance to angular leaf spot and mosaic were also chosen (in cooperation with the U.S. Agency for International Development).



## 2. Snap Beans

a. Disease resistance. The studies with white-seeded (D 7) mutants recovered from diethyl sulfate-treated seed has been discontinued since these mutants are weaker stemmed and leafier than the parent stock. A buff-seeded mutant (D 11) was isolated from Yakima (released in 1965), and several new white-seeded mutants (D 9) are being increased for processor trials. One of the latter is an extremely early type and is being used as parental stock in further crosses. Several early generation ( $F_4$  to  $F_6$ ), white-seeded breeding lines resistant to curly top and two mosaic viruses were released to private breeders for hybridization purposes to induce seedsmen to develop curly top-resistant varieties suitable for the Columbia Basin. Many new crosses were made for resistance to yellow bean mosaic, alfalfa mosaic, and to fusarium root rot, coupled with resistance to curly top and common bean mosaic viruses. Rust resistant studies at Salisbury, Maryland, are in progress.

The use of the cold test for screening potential rot rot-resistant material for the ability to germinate and emerge under adverse soil conditions has revealed a segregation for this character and appears to be associated with root rot resistance.

Inoculation tests with four races of anthracnose of the commonly grown El Salvadoran varieties showed that a large number were resistant to the beta and gamma races and may be the reason why this disease is uncommon there. Two varieties resisted the delta race whereas no American varieties resist this race.

A dwarf mutant character found in a breeding line was found to be a simple recessive in crosses with normal beans.

A number of accessions were found to have some resistance to Rhizoctonia on the basis of hypocotyl and root lesions. Some of these have been outstanding in 3 successive tests.

b. Nematode resistance. Breeding line B2971-1-1, and P.I. 165426 and P.I. 165435 indicated good to moderate resistance. Nematode resistance found in a hybrid cross between a susceptible bush type x P.I. 165426 appears to be superior to that present in an existing pole bean type.

## 3. Lima Beans

a. Downy mildew-resistant varieties. The first downy mildew-resistant, green-seeded Fordhook, U.S. 861, was released to the seed trade early in 1966.

Several very productive Jackson Wonder types, also resistant to the two strains of the organism, are being increased for commercial trials.

Resistant white-seeded Fordhook, U.S. 761, again showed promise in 1965 and will be tested commercially in 1966. It is 4 to 5 days earlier than Fordhook 242 and is a smaller plant.

Baby limas G 1 and G 2, resistant to the two strains of the downy mildew organism, will be tested commercially as processing types in 1966. They are very productive, later, and slightly larger than Thaxter.

b. Nematode resistance. Efforts are being made to incorporate resistance in Jackson Wonder type lima beans and other varieties using Nema-green as the resistant parent.

c. Stem anthracnose resistance. Several plants in P.I. lines 199791 from British Guinea and 186984 from South Africa were the only ones found resistant to the fungus and were crossed with Thaxter, Early Thorogreen, and Fordhook 242. The F<sub>3</sub> is now being produced. Races of the fungus will be investigated.

#### 4. English Peas

Disease resistance. Several hundred F<sub>2</sub> lines were screened in the greenhouse for resistance to common pea mosaic, enation mosaic, and powdery mildew, and good resistance was recovered to the several diseases. Screening for root rot (complex) resistance recovered a very low order of tolerance. Many new crosses were made among progenies with single- or multiple-disease-resistant factors.

#### 5. Cowpeas

Disease resistance. Two sources of powdery mildew resistance were observed--Vigna vexiculata P.I. 225934 and the variety White Blackeye. About 106 from 265 lines were resistant to Cladosporium leaf spot. No immunity was found to the Arkansas cowpea mosaic virus and the cowpea strain of the tobacco mosaic virus.

#### 6. Dry Peas and Lentils

In trials, 30 selected lines of yellow-seeded, 36 of Alaska and three of Scotch green peas, were superior in yield to commercial varieties of the respective types. From about 140 nonbleached types of Alaska and Scotch green peas, over 4,000 selections and 500 bulk lots were chosen for 1966 trials. Preliminary yield trials of 42 pure lines of lentils (5-7 mm in diameter) selected in 1964 showed all to be superior to leading commercial lines. From about 350 lines chosen in 1964, approximately 2,000 single plant selections and 475 bulks were made for 1966 trials.



## 7. Legumes for Iran and India

No actual breeding programs have been started since available germ plasm is being surveyed first for disease and insect resistance, adaptability, and related characters. In Iran, a chickpea from Cyprus was found to yield nearly 40% more and a cowpea variety from Lebanon, 21% more than the respective local varieties. Of the 10 high yielding dry bean varieties tested in two locations, six were U.S. varieties. In India, large seed collections of edible legumes are being made for evaluation in 1967.

### B. Diseases

#### 1. Beans and Lima Beans

a. Bean viruses. The following viruses are being studied: A new strain of common bean mosaic virus from a Plant Introduction from Mexico; a virus producing 2,4-D-like symptoms isolated from beans that appears to be related to cucumber mosaic virus; an apparently new strain of yellow bean mosaic virus producing symptoms identical to those of common bean mosaic virus, isolated from beans in Tennessee; and the peanut stunt virus, a new peanut virus from Virginia, which is being investigated on beans and other edible legumes to determine its relationships to the commonly reported virus diseases of beans and peas. Mild mottle, a strain of white clover mosaic virus, has been purified. The antigen of this virus stimulates the production of a high titer antiserum which is being used to study the serological relationships of certain bean viruses.

In the Northwest, red clover was the only cultivated forage legume from which viruses were spread naturally into nearby bean fields; and bean yellow mosaic virus was the only one to spread in significant amounts. Yellow bean mosaic virus predisposed beans to increased damage by fusarium root rot in two varieties.

b. Bacterial diseases. A rapid method to infect bean seed internally with the several bacterial organisms was devised by immersing seed in a bacterial suspension and subjecting them to a partial vacuum for less than 5 minutes. The use of this method provides a supply of internally infected seed necessary in studying the efficacy of chemical seed treatment.

The use of 1 percent streptomycin sulfate sprayed on bean seed (comparable to a slurry treatment) at the rate of 10 ounces of liquid per 100 pounds of seed controlled the halo blight organism as a surface contaminant under greenhouse conditions. Of 8 copper compounds tested as weekly sprays, Sol Kop-10, Calumet Coppers, and Calumet M-20 used at the rate of 1/2 gallon, 2 gallons, and 3 pounds per 100 gallons of water, respectively gave satisfactory field control of halo and common blights in Michigan.

c. Fungus diseases. Predisposition of beans to fusarium root rot was caused by yellow bean mosaic, crowding of plants, adverse soil temperatures and moisture, mechanical root restriction, or damage to foliage or roots. In a study of nematode-fungus interactions, Pratylenchus sp. but not Paratylenchus sp. increased root damage when added to soil naturally infected with the fusarium root rot of bean. Neither of the nematodes caused damage to the plants in the absence of the fungus.

## 2. English Peas

The most important cultural factor influencing pea root rot severity in central Washington is method and application of irrigation. Peas grown under sprinkler irrigation developed less root rot than those grown under rill irrigation when moderately or overirrigated.

## 3. Cowpeas

Studies on the effect of O<sub>2</sub> and CO<sub>2</sub> and anaerobic atmospheres on survival of nematodes attacking cowpeas indicate survival at 100% CO<sub>2</sub> concentrations. Continued studies on the survival on the cowpea wilt fungus showed that the fungus was able to grow under anaerobic conditions. The fungus proliferates aerobically by mycelial growth; but under anaerobic conditions, it produces masses of chlamydospores. Upon return to air, normal mycelial growth resumed within 72 hours.

## 4. Dry Peas

The foliage disease reported in 1964 from which a bacterium is consistently isolated developed in more serious proportions than in the two previous cropping seasons. The cause of this disease is still under investigation. Captan dust, Panogen 15, Captan slurry, Dieldrin, and Chipcote 75 as seed treatments significantly increased yields over the check.

## 5. Lentils

Root rots of lentils caused by Fusarium sp. and Botrytis cinerea, and powdery mildew were serious in 1965. Virus diseases were of minor importance except when planted adjacent to fields of alfalfa and clover.

## C. Variety Evaluation and Physiology

Chromatographic analyses for pod flavor studies indicate that no one chemical constituent is responsible for differences in flavor among varieties. Certain combinations of phenolic compounds can be factors influencing flavor.



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

Wester, R. E. 1965. Green cotyledon in lima beans, its origin and development. Seed World 96:30.

Diseases

- Andersen, Axel L. and Don M. Huber. 1965. The plate-profile technique for isolating soil fungi and studying their activity in the vicinity of roots. Phytopathology 55:592-594.
- Burke, D. W. 1965. Plant spacing and fusarium root rot of beans. Phytopathology 55:757-759.
- Burke, D. W. 1965. Fusarium root rot of beans and behavior of the pathogen in different soils. Phytopathology 55:1122-1126.
- Burke, D. W. 1965. The near immobility of Fusarium solani f. phaseoli in natural soils. Phytopathology 55:1188-1190.
- Burke, D. W. and C. E. Nelson. 1965. Effects of row and plant spacings on yields of dry beans in Fusarium-infested and noninfested fields. Wash. Agric. Expt. Sta. Bull. 664. 6 p.
- Burke, D. W. and M. J. Silbernagel. 1965. Testing beans for field tolerance to fusarium root rot. Phytopathology 55:1045-1046.
- Burke, D. W. 1966. Importance of lateral roots in fusarium root rot of beans. Phytopathology 56:292-294.
- Erdmann, M. H., L. S. Robertson, R. L. Jones, R. G. White, M. W. Adams, and A. L. Andersen. 1965. Field bean production. Mich. Sta. Univ. Cooperative Ext. Serv. Bull. 513. 10 p.
- Ford, Richard E. 1965. Enation symptoms in tobacco induced by alfalfa mosaic virus. Plant Dis. Reprtr. 49(8):684-686.
- Ford, R. E. and J. R. Baggett. 1965. Reactions of plant introduction lines of Pisum sativum to alfalfa mosaic, clover yellow mosaic, and pea streak viruses, and to powdery mildew. Plant Dis. Reprtr. 49(9):787-789.
- Ford, R. E. and J. R. Baggett. 1965. Relative severity of legume viruses in peas measured by plant growth reduction. Plant Dis. Reprtr. 49(9):627-629.
- Ford, R. E. 1965. Vetch pod rupture associated with unrelated streak-inducing viruses of peas. Phytopathology 55(8):935-936.
- Goth, R. W. 1965. Puncture method for isolating bacterial blights of bean. Phytopathology 55:930-931.
- Goth, R. W. and S. A. Ostazeski. 1965. Sporulation of Macrophomina phaseoli on propylene oxide-sterilized leaf tissues. Phytopathology 55:1156.
- Goth, R. W. and W. J. Zaumeyer. 1965. Reactions of bean varieties to four races of anthracnose. Plant Dis. Reprtr. 49:915-918.
- Goth, R. W. 1966. Golden Bantam corn seed, a suitable medium for the asexual sporulation of Cephalosporium gregatum. Plant Dis. Reprtr. 50:30-33.

- Goth, R. W. 1966. The use of a partial vacuum to inoculate bean seeds with pathogenic bacteria. *Plant Dis. Repr.* 50:110-111.
- Hampton, R. O. Nature of bean yield reduction by bean yellow mosaic virus. (Abstr.) *Phytopathology* 56:147.
- Hampton, R. O. 1966. Bean yellow mosaic: field spread from red clover. (Abstr.) *Phytopathology* 56:147.
- Hampton, R. O., M. D. Aichele, and E. C. Blodgett. 1966. Prunus effusa "Krassa Severa" as a prune dwarf virus index host. *Phytopathology* 56:65-69.
- Silbernagel, Matt J. 1965. Differential tolerance to curly top in some snap bean varieties. *Plant Dis. Repr.* 49:475-477.
- Silbernagel, Matt J. 1965. Snap bean disease survey in the Pacific Northwest. *Plant Dis. Repr.* 49:637-638.
- Sorger, George J., Richard E. Ford, and Harold J. Evans. 1965. Effects of univalent cations on the immunoelectrophoretic behavior of Pyruvic kinase. *Proc. Nat. Acad. Sci.* 54(6):1614-1621.
- Taylorson, R. B. and R. W. Toler. 1965. Preliminary experimentation on weed control in southern pea (*Vigna sinensis* (Torner) Savi). The Proceedings, 18th Annual Meeting of the Southern Weed Conference, Vol. 18.
- Toler, R. W., P. D. Dukes, and S. F. Jenkins, Jr. 1966. Growth response of Fusarium oxysporum f. tracheiphilum in vitro to varying oxygen and carbon dioxide tensions. *Phytopathology* 56:182-186.
- Webb, R. E. and R. W. Goth. 1966. A seedborne bacterium isolated from watermelon. *Plant Dis. Repr.* 49:818-821.
- Wester, R. E., R. W. Goth, and Charles Drechsler. 1966. Overwintering of Phytophthora phaseoli. *Phytopathology* 56:95-97.
- Wilson, V. E. and John Brandsberg. 1965. Fungi isolated from diseased lentil seedlings in 1963-64. *Plant Dis. Repr.* 49:660-662.

### Culture

- Andersen, Axel L. 1965. Dry bean production in the Lake and Northeastern States. *Agric. Handbook No. 285*. August.

## PUBLICATIONS -- STATE EXPERIMENT STATIONS

### Breeding, Culture and Physiology

- Barker, A. V., R. J. Volk, and W. A. Jackson. 1965. Effects of ammonium and nitrate nutrition on dark respiration of excised bean leaves. *Crop Science* 5(5):439-44. (N.C.).
- Brantley, B. B. 1965. Dixiecream, a new variety of southern pea for processing. *Ga. Expt. Sta. Leaflet No. 45*. (Ga.).
- Brantley, B. B., C. W. Kuhn, and Grover Sowell, Jr. 1965. Effect of cucumber mosaic virus on southern pea (Vigna sinensis). *Proc. Am. Soc. Hort. Sci.* 87:355-358. (Ga.).
- Coyne, D. P. 1965. Component interaction in relation to heterosis for plant height in Phaseolus vulgaris L., variety crosses. *Crop Science* 5(1):17-18. (Nebr.).



- Coyne, D. P., M. L. Schuster, and L. Harris. 1965. Inheritance, heritability, and response to selection for common blight (Xanthomonas phaseoli) tolerance in Phaseolus vulgaris field bean crosses. Proc. Am. Soc. Hort. Sci. 86:373-379. (Nebr.).
- Coyne, D. P., M. L. Schuster, and J. O. Young. 1965. A genetic study of bacterial wilt (Corynebacterium flaccumfaciens var. aurantiacum) tolerance in Phaseolus vulgaris crosses and the development of tolerance to two bacterial diseases in beans. Proc. Am. Soc. Hort. Sci. 87:279-285. (Nebr.)
- Dean, L. L. 1965. Idealight - A new snap bean resistant to mosaic and curly top. Idaho Bull. No. 442. (Idaho).
- Harding, J. and R. W. Allard. 1965. Genetic variability in highly inbred isogenic lines of the lima bean. Crop Science 5(3):203.
- Jyung, W. H., S. H. Wittwer, and M. J. Bukovac. 1965. The role of stomata in the foliar absorption of Rb by leaves of tobacco, bean and tomato. Proc. Am. Soc. Hort. Sci. 86:361-365. (Mich.).
- Lambeth, V. N. and R. C. Das. 1965. Growth regulator effects on top-root ratio and cation exchange capacity of snap bean and sweet corn roots. Proc. Am. Soc. Hort. Sci. 86:357-360. (Mo.).
- Ozbun, J. L., R. J. Volk, and W. A. Jackson. 1965. Effect of potassium deficiency on photosynthesis reductant by immature bean leaves. Crop Science 5(1):69-75. (N.C.).
- Ozbun, J. L., R. J. Volk, and W. A. Jackson. 1965. Effects of potassium deficiency on photosynthesis, respiration, and the utilization of photosynthetic reductant by mature bean leaves. Crop Science 5(6):497-500. (N.C.).
- Quinones, F. A. 1965. Correlations of characters in dry beans. Proc. Am. Soc. Hort. Sci. 86:368-372. (N.M.).
- Stewart, F. B. 1965. Row spacing of determinate, bunch-type southern peas. Proc. Am. Soc. Hort. Sci. 86:484-486. (Va.).
- Tucker, C. L. 1965. Inheritance of white and green seed coat colors in lima beans. Proc. Am. Soc. Hort. Sci. 87:286-287. (Calif.).
- Wallace, D. H. and H. M. Munger. 1965. Studies of physiological basis for yield differences. I. Growth analysis of six dry bean varieties. Crop Science 5(4):343-348. (N.Y.).

### Diseases

- Kendrick, J. B., Jr. and W. D. Wilbur. 1965. The relationship of population-density of Pythium irregulare to pre-emergence death of lima bean seedlings. Phytopathology 55:1064. (Calif.).
- Crossan, D. F. 1965. Field and greenhouse experiments for control of Rhizoctonia root rot of snap beans. Phytopathology 55:503. (Del.).
- Williams, F. J. 1965. A hypocotyl collar rot of Phaseolus vulgaris. Plant Disease Reporter 49:134. (Md.).
- Mirocha, C. J. and A. I. Zaki. 1965. Fixation of  $C^{14}O_2$  in the dark by fungus-infected bean, beet, barley and oat plants. Phytopathology 55:940-941. (Minn.).

- Zaki, A. I. and C. J. Mirocha. 1965. Carbon dioxide fixation by rust-infected bean plants in the dark. *Phytopathology* 55:1303-1308. (Minn.).
- Bateman, D. F. and R. D. Lumsden. 1965. Relation of calcium content and nature of pectic substances in bean hypocotyls of different ages to susceptibility to Rhizoctonia solani. *Phytopathology* 55:734-738. (N.Y.).
- Bateman, D. F. and D. P. Maxwell. 1965. Phenol oxidase activity in extracts of Rhizoctonia solani-infected hypocotyls of bean and its distribution in relation to lesion areas. *Phytopathology* 55:127. (N.Y.).
- Wallace, D. H. and R. E. Wilkinson. 1965. Breeding for Fusarium root rot resistance in beans. *Phytopathology* 55:1227-1231. (N.Y.).
- Schroeder, W. T. and R. Provvidenti. 1965. Breakdown of the er er resistance to powdery mildew in Pisum sativum. *Phytopathology* 55:1075. (N.Y.).



TOMATO, PEPPER, AND RELATED CROP BREEDING AND GENETICS,  
DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. The rapid progress toward total mechanization of the tomato harvest, particularly for processing, has forced drastic changes in most tomato improvement programs. Disease-resistant, prolific-fruited, small-vined varieties of high processing quality and possessing other qualities adapted to machine harvesting are needed now, particularly in the western, central, and eastern production areas. Such diseases as curly top, Verticillium wilt, leaf spots, and fruit rots are causing serious losses in certain areas. Mechanization of the southern tomato and pepper transplant industry is dependent upon basic physiological studies on tomato and pepper seed dormancy and germination, seedling nutrition, and epidemiology of several plant bed disease-inducing organisms. Quality of tomatoes harvested mature-green needs drastic improvement. Lack of fruit firmness, crack resistance, plant and fruit resistance to insects, fruit rot resistance, low pH, and high solids and viscosity of processed products are major problems confronting the tomato processors.

Production problems of peppers are similar to those of the tomato.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and application of known principles to growers' problems. Tomato breeding and genetic studies at Beltsville, Maryland, and Charleston, South Carolina, involve crossing, progeny selection, disease evaluation, fruit quality evaluation, selection for adaptability, and evaluation for mechanical harvesting capability. At Cheyenne, Wyoming, breeding is directed toward adaptability to the temperature extremes and low humidity of the Great Plains. Breeding for curly top virus resistance is done at Logan, Utah. Disease studies on early blight, gray leaf spot, Fusarium wilt, Verticillium wilt, anthracnose, and tobacco mosaic virus are conducted in controlled laboratory and field experiments at Beltsville, Maryland. Disease research at Tifton, Georgia, include bacterial spot, bacterial wilt, damping-off fungi, and southern blight of vegetable transplants. Epidemiology of bacterial canker is conducted at Cheyenne, Wyoming. At Prosser, Washington, investigations are directed toward the identification of strains of the curly top virus, variation in virulence of strains on tomato, and nature of resistance to curly top in tomato. Limited varietal evaluation is conducted at Beltsville, Maryland. Work on culture and nutrition of tomato and pepper plants is conducted at Tifton, Georgia.

Extramural research on biochemical nature of resistance to the curly top virus in tomatoes, beans, and sugar beets is being done cooperatively with the University of California at Berkeley.

Work is done in Yugoslavia on the production of male sterile pepper lines for use in hybrids and a search is being made for forms with easily detachable ripe fruit adapted to mechanical harvesting.

The Federal scientific effort devoted to research in this area totals 11 scientist man-years: 5.8 to breeding and genetics, 4.2 to diseases, and 1.0 to culture.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 87 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

##### 1. Tomatoes

a. Varietal releases. B 96, an early, determinate, multiple disease-resistant, crack-resistant tomato line was released to the seed trade as the variety Enterpriser. This variety performed well in the Southern Tomato Exchange program during a 3-year test period. The last two years in this program it ranked among the first three of all entries entered in the yield trials. Many southern breeders have used Enterpriser (B 96) in their development programs for its disease resistance, to improve fruit set, and because of the smallness of the blossom scar.

The paste-type, Verticillium and Fusarium wilt-resistant tomato line, B 854, was released to the seed trade as the variety Harvester. Harvester (B 854) is earlier than the standard paste variety Roma, has a smaller vine, and proved adapted to mechanical harvesting in California in 1965. Yield trials and fruit quality evaluations in Maryland, New Jersey, Ohio, Utah, and California indicated a wide range of adaptability and highly acceptable processing quality. Fruit size is slightly smaller than Roma.

Highlander, an early, determinate, multiple disease-resistant variety adapted to many areas of the High Plains was released in 1965. Processing quality of fruit by a commercial processor indicated Highlander highly acceptable to the processors as well as to the fresh market.

CVF-4, an early, Verticillium and Fusarium wilt-resistant breeding line, highly resistant to the destructive curly top virus was released to private and public tomato breeders. Curly top exposure trials in Utah, Idaho, and Washington indicated resistance to strains of the virus that occurs in those areas. Also, earliness, productiveness, and fruit size indicate this germplasm to have a wide range of adaptability.



b. Breeding for curly top resistance in the tomato. Extensive field and greenhouse tests at Logan, Utah, and Prosser, Washington, indicate that resistance to the curly top virus is being rapidly incorporated into near commercial tomato lines.

c. Breeding for fruit set at low and high temperatures. Parental stocks and progenies were evaluated at Cheyenne, Wyoming, over the past 2 years for fruit set at low night temperatures and at Crystal City, Texas, for fruit set at high night temperatures. Breeding line B 87 and plants in several progenies have set consistently at both locations.

d. Breeding for high internal fruit color. At Charleston, South Carolina, the crimson character is being incorporated into lines adapted for green-wrap production. Preliminary tests indicate a definite advantage of the crimson character for artificial ripening of the detached tomatoes. Inheritance studies of the crimson character indicate that the low beta-carotene content in crimson fruits is due to a single recessive gene. The intermediate nature of the  $F_1$  and a 1:2:1 segregation ratio in the  $F_2$  indicate incomplete dominance for the gene controlling beta-carotene.

Data on lycopene content in segregating populations have been erratic, but a significant negative correlation has been established for the beta-carotene and lycopene contents. These data show that the pigment fractions are dependent and are probably controlled by the same genetic factor. The crimson gene has been shown to be effective in the presence of the lycopene inhibiting gene at. Crosses between crimson and at at are being used to study the effects of the crimson gene on pigment development.

e. Breeding for resistance to insects in the tomato. At Beltsville, Maryland, breeding lines among multiple disease-resistant stocks and varieties were isolated that were much less attractive to the drosophila fruit fly and reduced the multiplication of the spider mites. These have been crossed with high quality lines that show promise for mechanical harvesting. The nature of the factors affecting resistance to spider mites and drosophila are under study (cooperative with Entomology Research Division).

## B. Diseases

### 1. Tomato

a. Identification of causal agent of disease through serology. At Tifton, Georgia, and Cheyenne, Wyoming, an antiserum specific for Corynebacterium michiganense, casual agent of bacterial canker, was prepared and is in use as a technique for evaluating stocks for resistance to this serious disease.

At Tifton, Georgia, an antiserum was developed that is specific for 3 races of southern bacterial wilt of tomato and other crops. These antisera will aid in determining epidemiology of the disease as well as native hosts in uncropped lands.

### C. Culture and Physiology

#### 1. Tomato and pepper

a. Nutrition. At Tifton, Georgia, further evidence was obtained that nutrition was important to maximum yields of highly uniform tomato and pepper transplants. Of the major elements, nitrogen levels affected uniformity most.

Preliminary investigations indicated that tomato transplants may be "stored" in the field up to 2 weeks by clipping the plants when 8 to 10 inches tall.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Breeding and Genetics

- Davis, D. W., R. E. Webb, and B. D. Thyre. 1965. New paste tomato lines developed by USDA. *Amer. Vegetable Grower* 13(10):28.
- Davis, D. W., and A. K. Stoner. 1966. Comparison of several rapid methods of juice extraction in soluble solids determination of tomato. *HortScience* 1:18-19.
- Martin, Mark W. 1966. Release of a tomato breeding line CVF-4, with combined resistance to curly top, *Verticillium* wilt and *Fusarium* wilt. *Vegetable Improvement Newsletter*.
- Thyre, B. D., Gene S. Howard, and R. L. Fosket. 1966. Highlander, a new tomato variety. *Vegetable Grower J.* 14(1):20.
- Wann, E. V., W. A. Hills, and E. J. King. 1966. The expression of crimson in the presence of at at. *Tomato Genetics Coop. Report* 16:39-40.
- Webb, R. E., William S. Porte, and D. W. Davis. 1966. Enterpriser, a new tomato variety to be released by the USDA. *Amer. Vegetable Grower* 14(1):20.

### Diseases

- Morton, Donald J., and Robert W. Toler. 1965. Serological methods for quick detection of bacterial spot on pepper and tomato plants. *Ga. Agr. Res.* 6(4):14-15.
- Morton, D. J., P. D. Dukes, and S. F. Jenkins, Jr. 1966. Serological relationships of races 1, 2 and 3 of *Pseudomonas solanacearum*. *Plant Dis. Repr.* 50:275-277.
- Morton, D. J., and B. D. Thyre. 1966. Serologically diagnosing bacterial canker of tomato. *Plant Dis. Repr.* 50:96-97.



## Culture

- Jaworski, C. A. 1965. Effect of dolomitic limestone on tomato transplant growth, quality, and mineral composition. Proc. Fla. State Hort. Soc. 78.
- Valli, V. J., and C. A. Jaworski. 1965. Influence of biometeorological factors in tomato transplant production. Proc. Fla. State Hort. Soc. 78.

### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Abdul-Baki, A. A., J. P. McCollum, and D. B. Dickinson. 1965. The respiratory pattern in the tomato fruit and its alteration by infiltration with various chemicals. Plant Physiol. 40(4):611-614. (Ill.)
- Austin, M. E., and S. K. Ries. 1965. Predicting the harvest date for harvesting tomatoes mechanically. Proc. Amer. Soc. Hort. Sci. 86:587-596. (Mich.)
- Cordner, H. B., Hugh Thomson, and Charles Galeotti. 1965. Origin and development of the Nemared tomato. Okla. Exp. Sta. Bull. B-635. 19 pages. (Okla.)
- Davis, R. M., Jr., P. G. Smith, V. H. Schweers, and R. W. Scheuerman. 1965. Independence of floral fertility and fruit-set in the tomato. Proc. Amer. Soc. Hort. Sci. 86:552-556. (Calif.)
- Davis, R. M., Jr., P. G. Smith, V. H. Schweers, and R. W. Scheuerman. 1965. Relationships between fruit-set and developing fruit load in tomato. Proc. Amer. Soc. Hort. Sci. 86:557-564. (Calif.)
- Dempsey, A. H. 1965. Fertilizer placement and soil chiseling studies with Pimentos. Ga. Exp. Sta. Bull. 144. 14 pages. (Ga.)
- Dempsey, W. H., and J. E. Boynton. 1965. Effect of seed number on tomato fruit size and maturity. Proc. Amer. Soc. Hort. Sci. 86:575-581. (Calif.)
- Dickinson, D. B., and J. B. Hanson. 1965. Comparison of mitochondria from tomato fruits at various states of ripeness. Plant Physiol. 40(1):161-165. (Ill.)
- Ells, James E. 1965. Prevention of stand losses in tomato due to soil crust formation. Proc. Amer. Soc. Hort. Sci. 87:433-437. (Colo.)
- Elmstrom, G. W., and I. G. Hillyer. 1965. Internal moisture stress in tomato measured by relative turgidity and soluble solids in leaves. Proc. Amer. Soc. Hort. Sci. 86:569-574. (Ill.)
- Hall, C. B., and J. T. Mullins. 1965. Cellulase activity in sterile tomato fruits. Nature 206(4984):638-639. (Fla.)
- Hernandez, Teme P., Julian C. Miller, and M. J. Giamalva. 1965. Inheritance of resistance to root-knot nematodes, Meloidogyne incognita group, in tomatoes. Proc. Amer. Soc. Hort. Sci. 87:412-414. (La.)
- Knavel, D. E. 1965. Influence of container, container size, and spacing on growth of transplants and yields in tomato. Proc. Amer. Soc. Hort. Sci. 86:582-586. (Ky.)
- Knavel, Dean E., Hubert C. Mohr, and Carl E. Chaplin. 1965. Reaction of tomato varieties to Verticillium wilt and movement of the organism through grafted plants. Proc. Amer. Soc. Hort. Sci. 87:415-419. (Ky.)

- Phatak, S. C., and S. H. Wittwer. 1965. Regulation of tomato flowering through reciprocal top-root grafting. Proc. Amer. Soc. Hort. Sci. 87: 398-403. (Mich.)
- Thompson, A. E. 1965. A technique of selection for high acidity in the tomato. Proc. Amer. Soc. Hort. Sci. 87:404-411. (Ill.)
- Yamada, Y., W. H. Jyung, S. H. Wittwer, and M. J. Bukovac. 1965. The effects of urea on ion penetration through isolated cuticular membranes and ion uptake by leaf cells. Proc. Amer. Soc. Hort. Sci. 87:429-432. (Mich.)
- McIntyre, G. A. 1965. Absence of pectic plugs in tomato cuttings treated with polygalacturonases of Verticillium albo-atrum. Phytopathology 55 (10):1067. (Maine)
- Morehart, A. L., and D. F. Crossan. 1965. Studies on the Ethylenebisdithiocarbamate fungicides. Del. Agr. Expt. Sta. Bull. 357:1-26. (Del.)
- Wiebel, F. J., D. F. Crossan, and D. J. Fieldhouse. 1965. Evaluation of bacterial and non-bacterial compounds for control of bacterial spot of pepper. Plant Dis. Reprtr. 49(9):748-750. (Del.)
- Wiebel, F. J., and D. F. Crossan. 1965. The effect of nonbactericidal and bactericidal chemicals on Xanthomonas vesicatoria. Phytopathology 55(5): 506. (Del.)



LEAFY AND MISCELLANEOUS VEGETABLE BREEDING AND GENETICS,  
DISEASES, VARIETY EVALUATION AND CULTURE

Crops Research Division, ARS

Problem. The lettuce work is aimed fundamentally at improving seed uniformity and providing the grower with some measure of control over his disease problems. The lettuce grower in the Southwest at the moment is primarily concerned with problems of mechanization, including lack of varieties with seedlings that emerge promptly and uniformly, and mature within a narrow time limit. Added to the hazards are several serious diseases, largely uncontrolled, or at best only partially controlled.

Improvements in non-bolting, hardiness, disease-resistance, and yield of cabbage are needed. Further work is needed on development of  $F_1$  hybrids of crucifers and spinach. New breeding principles must be developed to improve range of adaptability and dependability of varietal and hybrid performance in mechanized production and processing.

USDA AND COOPERATIVE PROGRAM

Work on lettuce is conducted at Brawley, La Jolla, and Salinas, California; and Weslaco, Texas. At Brawley and La Jolla the research is designed to develop disease-resistant and better adapted varieties of head lettuce for the Southwest. At Salinas, efforts are directed mainly at developing disease-resistant varieties, the development of techniques necessary for the production of  $F_1$  hybrids using male steriles, basic studies of genetic mutants, and the inheritance of such quantitative characters. At Weslaco efforts are concentrated on developing varieties resistant to downy mildew and adapted to culture in the Lower Rio Grande Valley.

At Charleston, South Carolina, work is done to develop disease-resistant, hardy, non-bolting, productive cabbage of high quality for the Southeast and to develop basic genetic information. Work is done at Beltsville, Maryland, to develop multiple disease-resistant, high quality, longstanding spinach varieties and hybrids adapted to the Eastern and Southern United States.

The Federal scientific effort now devoted to this area totals 2.5 scientist man-years for breeding and genetics.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 43 scientist man-years is devoted to this area of research.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Breeding and Genetics

#### 1. Lettuce

a. Breeding line release. Line 50588-M, a small, uniform, head lettuce type of excellent quality, resistant to downy mildew, and tolerant to tip-burn, has been sent to those lettuce breeders requesting seed. This line, because of its stature and uniformity, is well adapted to bulk harvesting by mechanical means.

b. Breeding line performance. In field tests over the past two seasons, one line, M-16, has been outstanding for mid-season harvest. In yield and quality M-16 has been superior to the best commercial cultivars. Head size, color, freedom from freeze damage, and appearance of the butts in the carton, all excel the commonly used cultivars. It is less damaged by the new race of downy mildew than the commercial cultivars.

c. Inheritance studies. Three genetic studies are virtually complete. (1) A male sterile found in the crisphead variety Calmar is inherited as a single recessive. (2) A character discovered in a big vein resistant progeny confers a golden color to the flower compared to the normal yellow and produces chlorophyll deficient leaves in very early growth stages. It is inherited as a single recessive. (3) A direct relationship between type of anthocyanin pigmentation in leaves and involucre bracts has been shown. Plants classified as red (RR) show red streaks in the involucre; plants classified as tinge (rr) show red spots; and plants classified as heterozygous red (Rr) show both spots and streaks.

d. Resistance to mosaic. In the Central-coastal District of California, significant progress has been made in breeding for resistance to lettuce mosaic. Evidence is accumulating to show that resistance derived from P.I. 251245, an introduction of Lactuca serriola from Egypt, will be useful in crosses with Lactuca sativa. Two genes, one dominant and one recessive, may be responsible for resistance.

#### 2. Spinach Improvement

a. Breeding line release. Seed increases of line S498, a savoy type immune to 2 races of mildew are being made for release to seedsmen in November. S498 was outstanding in fall and winter production areas as a line, as well as in hybrid combinations.

b. Longstanding line and hybrid evaluations. In New Jersey, 4 flat types, each representing a different leaf texture and color, and 2 savoy types were promising in over-winter and spring plantings for extending the harvest



period into June. In Maryland, trials of 69 lines and experimental hybrids demonstrated real progress in incorporating immunity to 2 races of mildew and spinach blight into both longstanding smooth and savoy leaf types adapted to eastern growing conditions. In Texas, pilot plantings on a commercial scale indicated experimental hybrid S<sup>4</sup>65 x S598 to be superior in early vigor and productivity than Early Hybrid No. 7.

### 3. Cabbage

a. Studies on inbred line development. At Charleston, South Carolina, a second experiment has confirmed previous results showing that some cabbage lines are entirely self-pollinated. Development of such self-pollinated lines under controlled conditions would facilitate the formation of new hybrids.

b. Studies on glaze selections. Glaze selections continue to have superior quality, but seed production has generally been low for most of the lines. Some glaze lines have been highly self-incompatible, as well as cross-incompatible, among plants of a particular line. A recent observation of a high incidence of powdery mildew on the glaze selections is considered significant when compared with the lower incidence on those varieties having bloom.

c. Sources of disease resistance. A new source of black rot resistance was recently found in P.I. 303629 from South Africa. This line needs additional testing both in the greenhouse and field.

### B. Diseases

#### 1. Lettuce

a. Mosaic in relation to seed yields and maturity. A joint study with Sugarbeet Investigations shows that lettuce mosaic and beet western yellows separately and together significantly reduced lettuce seed yield and delayed seed maturity in the greenhouse.

b. New race of mildew. In Texas, the single most outstanding event of the lettuce season was the appearance of what is believed to be a new biological race of the downy mildew organism. All varieties and lines previously immune to downy mildew were fully susceptible or susceptible in some degree to the new race of the organism. Field observations indicate there is a wide range of susceptibility to the new race of mildew. Valverde, Valmaine, and 50588-M displayed the most resistance, while Calmar and M-14 were most susceptible. Great Lakes 6238, G. L. R-200, and G. L. 659 were about intermediate in reaction.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics

- Ryder, E. J. 1965. The inheritance of five leaf characters in lettuce (Lactuca sativa L.). Proc. Amer. Soc. Hort. Sci. 86:457-461.
- Whitaker, T. W. 1966. Reviews: "Essays on Crop Plant Evolution" edited by Sir Joseph Hutchinson; "Agricultural Genetics" by James L. Brewbaker; "Plant Hybridization Before Mendel" by H. F. Roberts; and "Kurze Geschichte der Genetik bis zur Wiederentdeckung der Vererbungsregeln Gregor Mendels" by Hans Stubbe. Plant Life 22:125-127.

Variety Evaluation

- Perry, B. A., R. E. Webb, and D. M. McLean. 1965. Dixie Savoy Spinach. J. Rio Grande Valley Hort. Soc. 19:95-97.
- Whitaker, T. W. 1965. Oak-leafed lettuce; a dependable variety for the Mid-West. Mo. Bot. Garden Bull. 53(4):1-2.

Culture

- LeBaron, F. C., G. A. Sanderson, and T. W. Whitaker. 1965. Thinning by machine. Amer. Veg. Grower 13(4):16, 18, 21, 32.
- Whitaker, T. W., and A. J. Mackenzie. 1965. Choosing land for winter lettuce. Western Grower & Shipper 36(9):24.
- Whitaker, T. W., and H. C. Cutler. 1966. Food plants in a Mexican market. Econ. Bot. 20(1):6-16.

PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Brown, L. D., and R. L. Carolus. 1965. An evaluation of fertilizer practice in relation to nutrient requirement of asparagus. Proc. Amer. Soc. Hort. Sci. 86:332-337. (Mich.)
- Foley, R. F. 1965. Some solar radiation effects on vegetable crops in Idaho. Proc. Amer. Soc. Hort. Sci. 87:443-448. (Id.)
- Honma, S. 1965. Development and maintenance of uniformity in broccoli (Brassicae oleraceae var. italica). Proc. Amer. Soc. Hort. Sci. 87:295-298. (Mich.)
- Irizarry, H., J. H. Ellison, and Portia Orton. 1965. Inheritance of persistent-green color in Asparagus officinalis L. Proc. Amer. Soc. Hort. Sci. 87:274-278. (N. J.)
- Ito, P. J., and T. M. Currence. 1965. Inbreeding and heterosis in asparagus. Proc. Amer. Soc. Hort. Sci. 86:338-346. (Minn.)
- Maynard, D. N., B. Gersten, and H. F. Vernell. 1965. The distribution of calcium as related to internal tipburn, variety, and calcium nutrition in cabbage. Proc. Amer. Soc. Hort. Sci. 86:392-396. (Mass.)



- Robinson, F. E., and O. D. McCoy. 1965. The effect of sprinkler irrigation with saline water and rates of seeding on germination and growth of lettuce. *Proc. Amer. Soc. Hort. Sci.* 87:318-323. (Calif.)
- Struckmeyer, B. Esther, and T. W. Tibbitts. 1965. Anatomy of lettuce leaves grown with a complete nutrient supply and without calcium or boron. *Proc. Amer. Soc. Hort. Sci.* 87:324-329. (Wisc.)
- Tibbitts, T. W., B. Esther Struckmeyer, and R. R. Rao. 1965. Tipburn of lettuce as related to release of latex. *Proc. Amer. Soc. Hort. Sci.* 86:462-467. (Wisc.)
- Tompkins, D. R. 1965. Rhubarb rest period as influenced by chilling and gibberellin. *Proc. Amer. Soc. Hort. Sci.* 87:371-379. (Wash.)
- Wann, E. V., and A. E. Thompson. 1965. Anthocyanin pigments in asparagus. *Proc. Amer. Soc. Hort. Sci.* 87:270-273. (Ill.)
- Zink, F. W. 1965. Growth and nutrient absorption in spring spinach. *Proc. Amer. Soc. Hort. Sci.* 87:380-386. (Calif.)
- Walker, J. C., P. H. Williams, and G. S. Pound. 1965. Internal tipburn of cabbage, its control through breeding. *Wisc. Agr. Expt. Sta. Res. Bull.* 258, 11 pp. (Wisc.)
- Walker, J. C., and P. H. Williams. 1965. The inheritance of powdery mildew resistance in cabbage. *Plant Dis. Reprtr.* 49(3):198-201. (Wisc.)

MUSKMELON AND OTHER CUCURBIT BREEDING AND GENETICS, DISEASES,  
VARIETY EVALUATION AND CULTURE

Crops Research Division, ARS

Problem. Major problems of muskmelons and related crops are poor fruit quality and low yields caused by lack of adapted varieties resistant to several major diseases. Diseases seriously reduce yields and impair fruit quality in some regions of production each year. Cucurbits, particularly muskmelons and cucumbers, adapted to machine harvesting are needed to reduce production costs. Potentials of  $F_1$  hybrids and methods of their production needs extensive study. Improvements in breeding methods are needed to increase efficiency of breeding programs.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-term program involving geneticists, horticulturists, and plant pathologists engaged in both basic and applied research on melons and other cucurbits. Extensive muskmelon and squash breeding and genetic studies are conducted at La Jolla and Brawley, California; Charleston, South Carolina; and Beltsville, Maryland. Watermelon breeding is done at Charleston. Disease research with emphasis on crown blight of muskmelon is done at Beltsville, Maryland; and Mesa and Tucson, Arizona, in cooperation with the Arizona Agricultural Experiment Station.

Work on experimental control of morphogenesis in cucurbits is done in Israel.

The Federal scientific effort devoted to research on melons and other cucurbits totals 4.6 scientist man-years: 2.7 are devoted to breeding and genetics, 1.4 to diseases, and .5 to variety evaluation.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 61 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding and Genetics

1. Muskmelon

a. Breeding for multiple disease resistance. In cooperation with Arizona, California, and Texas, powdery mildew and crown blight-resistant breeding lines were evaluated in growers' fields for adaptability and resistance to disease. A Honey Dew breeding line with high resistance to powdery mildew and crown blight and moderate resistance to downy mildew was judged to be superior to commercial Honey Dew at several locations. Seed of this line was increased for further advanced trials.



- b. New varieties. Grower trials of the cantaloup varieties Campo and Jacumba, released in 1964 and 1965, indicate their ability to improve yields and quality in the early spring districts of the West.
- c. Mechanical harvesting. Results of cooperative breeding work between La Jolla and Davis, California, in attempts to transfer the bush character into cantaloups suitable for machine harvesting indicate that the barriers of small size and poor fruit quality characteristics of the bush types have been broken.
- d. Resistance to downy mildew in muskmelons. The new variety Perlita, a product of cooperative effort of the Texas Agricultural Experiment Station with the U. S. Department of Agriculture, has proved its usefulness to commercial growers in the Lower Rio Grande Valley. Perlita was the only variety to produce a marketable crop in this area in the spring of 1966 due to its relative resistance to downy mildew.
- e. Resistance to nematodes. Cucumis species with resistance to the root-knot nematode (Meloidogyne incognita acrita) are being used in attempted crosses with C. melo and C. sativus. No  $F_1$  plants from crosses between C. melo and other species have been obtained thus far. A successful cross between C. hardwickii and C. sativus has been made and the fertile hybrid may provide a bridge between C. sativus and Cucumis species with nematode resistance.
- f. Resistance to insects. Plants from 16 species of vine crops were tested for feeding stimulants by using banded cucumber beetles (Diabrotica balteata). Feeding stimulants were present in highly significant amounts in Cucumis heptadactylus and C. ficifolius. C. metuliferus and C. hardwickii lacked the stimulant. Tests on C. hookeri, C. prophetarum, C. dinteri, C. hirsutis, C. anguria x hookeri, C. africanus, C. zeyhari, C. asper, and C. anguria indicated varying small quantities of feeding stimulant (cooperative with the Entomology Research Division).
- g. Development of breeding methods. Analysis of means and coefficients of variability demonstrated that index mass-selection is a powerful tool to simultaneously improve 15 or more fruit characters in the cantaloup without loss of potential for further improvement. Mass-selected populations and inbreds from late generation mass lots were relatively free from plant defects that frequently occurred in inbreds from early generation mass lots. Six or more generations of mass-selections are recommended to precede strict inbreeding in cantaloup hybrids.
- h. Experimental morphogenesis in cucurbits. In cooperation with Israel, studies were continued to determine factors controlling sex differentiation in cucumber and muskmelon. Of three base analogues added to the cultural medium for in vitro cultured floral needs, 2-thiouracil was found to exert

the greatest influence on differentiation of sex organs in ontogeny of floral buds of cucumber and muskmelon. Environmental conditions were found to have a profound influence on sex expression in cucumber; ratio of male to female flowers was greatest under long days and high temperatures.

i. Genetics and cytogenetics. Progeny tests of plants resistant to cotton swab-carborundum inoculation with cucumber mosaic virus demonstrated that such plants may be homozygous or heterozygous for resistance. Therefore, resistance is controlled by more than the postulated 2 recessive factors. Graft-transfer separated the resistant plants into two fractions. Preliminary results indicate this tool may permit us to resolve the complex genetic mechanism controlling resistance.

Six phenotypic responses to watermelon mosaic virus have been observed in successive backcrosses to mottle: mottle, seedling lethal, systemic necrosis (delayed lethal), blade primary fleck, vein primary fleck, and symptom-free. Work is in progress to determine the genotypes of the different phenotypes.

F<sub>2</sub> linkage tests of seedling and young plant markers indicated independent assortment, or possibly loose linkage between the powdery mildew resistance gene, Pm<sup>2</sup>, and markers b, bush: gl glabrous: ms<sup>1</sup>, male-sterile 1: ms<sup>2</sup>, male-sterile 2: n, necterless: r, red stem, and y, yellow-green. Similar tests indicated independent assortment between male-steriles and most seedling markers. A suitable marker would facilitate the commercial production of F<sub>1</sub> hybrid seed. Similarly, a marker linked with disease-resistance genus would facilitate selection for resistance in the absence of epiphytotics in field tests. Red stem, a potentially valuable young plant marker from P.I. 157083, was found to be inherited as a simple Mendelian trait.

## 2. Watermelon

a. Breeding for polyploids. Among the 18 experimental diploid F<sub>1</sub> hybrids there are 4 which would be commercially useful if promoted by a commercial seed firm. The Laboratory is prepared to release one or two additional breeding lines which have proved their usefulness as parents in hybrid production so they will be available to private breeders.

b. Variety evaluation and physiology. Selection No. 60-27 stock, a wilt-resistant, extra large, round melon with a Congo stripe, has been tried by several commercial growers in South Carolina. All growers have liked this melon and coveted more seed, apparently because of its attractive appearance and the fact that it will sell well in a market glutted with Charleston Gray.

c. Resistance to anthracnose. A re-survey of watermelon accessions, previously thought to be resistant to race 2 anthracnose, shows that none



of them in fact have any important level of resistance to this more virulent form of Colletotrichum. Tests of polyploids show that there is no multiple-genome effect on resistance to either race 1 or race 2.

## B. Diseases

### 1. Muskmelon

a. Virus assays in cucurbits. In cooperation with Florida, Texas, Arizona, and California, assays of diseased specimens from watermelon and cantaloup indicated that only watermelon mosaic virus 1 (WMV-1) was present in watermelons in the Immokalee area of Florida; WMV-1, WMV-2, cucumber mosaic virus (CMV), and tobacco ringspot virus (TRSV) in cantaloup and watermelon in the Lower Rio Grande Valley of Texas; WMV-1 (one isolate only), WMV-2, CMV, and muskmelon necrotic fleck virus (MNFV) from cantaloups in the Salt River Valley of Arizona; and WMV-1 (2 isolates only), WMV-2, and CMV from cantaloups in the Imperial Valley of California.

b. Crown blight of cantaloup. Studies at Beltsville, Maryland, under greenhouse conditions conducive to the development of crown blight indicated varieties Edisto 47, Texas Resistant No. 1, and Rio Gold to be the most resistant of 10 varieties and 12 multiple resistant breeding lines.

c. Seedborne bacterium of watermelon. At Beltsville, Maryland, a seedborne bacterium was isolated from two watermelon seed lots. The bacteria had survived in the two seed lots 4 and 6 years, respectively. Seed treatment with several chemicals failed to rid artificially infested seed of the organism. A varietal trial of 45 watermelon varieties indicated that some varieties were very highly resistant to seed transmission of the bacteria while others were completely susceptible.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Breeding and Genetics

Bemis, W. P., and T. W. Whitaker. 1965. Natural hybridization between Cucurbita digitata and C. palmata. Madrono 18(2):39-47.

Bohn, G. W., and J. A. Principe. 1964. A second male-sterility gene in the muskmelon. J. Hered. 55:211-215.

Bohn, G. W., G. N. Davis, R. E. Foster, and T. W. Whitaker. 1965. Campo and Jacumba. New varieties for the Southwest. Calif. Agr. 19(7):8-10.

Whitaker, T. W. 1965. Squash x wild gourd = resistance against mildew. Agr. Res. 14(8):2.

## Diseases

- Foster, R. E., and R. E. Webb. 1965. Temperature effects on symptom expression and concentration of six muskmelon viruses. *Phytopathology* 55(9):981-985.
- Webb, R. E., G. W. Bohn, and H. A. Scott. 1965. Watermelon mosaic viruses 1 and 2 in Southern and Western cucurbit production areas. *Plant Dis. Reprtr.* 49(6):532-535.
- Webb, R. E., and H. A. Scott. 1965. Isolation and identification of watermelon mosaic viruses 1 and 2. *Phytopathology* 55(8):895-900.
- Webb, R. E., and R. W. Goth. 1965. A seedborne bacterium isolated from watermelon. *Plant Dis. Reprtr.* 49(10):818-821.
- Webb, R. E. 1965. Luffa acutangula for separation and maintenance of watermelon mosaic virus 1 free of watermelon mosaic virus 2. *Phytopathology* 55(12):1379-1380.
- Webb, R. E., and R. E. Foster. 1966. A strain of the tobacco mosaic virus isolated from muskmelon. *Plant Dis. Reprtr.* 50(1):49-52.

## Culture

- Davis, G. N., T. W. Whitaker, G. W. Bohn, and R. F. Kasmire. 1965. Muskmelon production in California. *Calif. Agr. Expt. Sta. Circ.* 536: 39 pp.
- LeBaron, F. C., G. A. Sanderson, and T. W. Whitaker. 1965. Thinning by machine. *Amer. Veg. Grower* 13(4):16, 18, 21, 32.
- Standridge, R. O., G. A. Sanderson, and T. W. Whitaker. 1965. A money saving mulcher for melons. *Western Grow. & Ship.* 36(6):25.
- Whitaker, T. W., and H. C. Cutler. 1965. Cucurbits and cultures in the Americas. *Econ. Bot.* 19(4):344-349.
- Whitaker, T. W. 1966. Gourds and people. *Parks Floral Magazine* 65(6):19-26. (Reprinted from *Amer. Hort. Magazine*)

## PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Brasher, E. P. 1965. The golden perfection cantaloupe (muskmelon). Del. *Agr. Expt. Sta. Bull.* 355. 4 pages. (Del.)
- Davis, G. N., and U. G. H. Meinert. 1965. The effect of plant spacing and fruit pruning on the fruits of P.M.R. No. 45 cantaloupe. *Proc. Amer. Soc. Hort. Sci.* 87:299-302. (Calif.)
- Flocker, W. J., J. C. Lingle, R. M. Davis, and R. J. Miller. 1965. Influence of irrigation and nitrogen fertilization on yield, quality, and size of cantaloupes. *Proc. Amer. Soc. Hort. Sci.* 86:424-432. (Calif.)
- Foster, R. E. 1965. The effect of pH on rooting Cucumis melo L. cuttings and the influence of cuttings on solution pH. *Proc. Amer. Soc. Hort. Sci.* 86:446-450. (Ariz.)
- Foster, R. E., and Margaret O. Foster. 1965. Effects of six viruses on root initiation in muskmelon (Cucumis melo L.). *Proc. Amer. Soc. Hort. Sci.* 87:330-334. (Ariz.)



- Jaffe, M. J., and F. M. Isenberg. 1965. Some effects of N-Dimethyl amino succinamic acid (B-Nine) on the development of various plants with special reference to the cucumber, Cucumis sativus L. Proc. Amer. Soc. Hort. Sci. 87:420-428. (N. Y.)
- Jones, C. M. 1965. Effects of benzyladenine on fruit set in muskmelon. Proc. Amer. Soc. Hort. Sci. 87:335-340. (Ind.)
- Nath, P., and C. V. Hall. 1965. The genetic basis for cucumber beetle resistance in Cucurbita pepo L. Proc. Amer. Soc. Hort. Sci. 86:442-445. (Kan.)
- Rowe, P., and J. L. Bowers. 1965. The inheritance and potential of an irradiation induced tendrillless character in cucumbers. Proc. Amer. Soc. Hort. Sci. 86:436-441. (Ark.)
- Schroeder, C. A. 1965. Temperature relationships in fruit tissues under extreme conditions. Proc. Amer. Soc. Hort. Sci. 87:199-203. (Calif.)
- Stoner, A. K., and K. W. Johnson. 1965. Overcoming autosterility of autotetraploid watermelons. Proc. Amer. Soc. Hort. Sci. 86:621-625. (Ill.)
- Tomes, M. L., and K. W. Johnson. 1965. Carotene pigments of an orange-fleshed watermelon. Proc. Amer. Soc. Hort. Sci. 87:438-442. (Ind.)
- Leben, C. 1965. Influence of humidity on the migration of bacteria on cucumber seedlings. Canadian J. Microbiol. 11(4):671-676. (Ohio)
- Mahadevan, A., J. Kuc', and E. B. Williams. 1965. Biochemistry of resistance in cucumber against Cladosporium cucumerinum. I. Presence of a pectinase inhibitor in resistant plants. Phytopathology 55(9):1000-1003. (Ind.)

FLOWER AND ORNAMENTAL PLANT BREEDING AND GENETICS,  
DISEASES, AND CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Technical problems in the production of flowers and ornamental plants (with a farm value of over a half billion dollars a year), are varied and numerous. There is lack of research on photoperiodicity, genetics, breeding, pathology, and adaptability of these commercially important plants. Varieties resistant to disease and insect pests and adapted to the expanding urban environment are needed. More attractive flowers and plants with better keeping quality must be produced to compete for a share of the consumer's dollar. More precise control of growth and timing of the crops must be developed to increase efficiency and to meet specific market demands. The industry is demanding answers to these problems. The great expansion of commercial cut flower production out-of-doors is attended by many new problems. Explosive urbanization and expanding interest in civic beautification bring new and more urgent needs for answers to old problems. This group of crops, for which consumer demand is highly elastic, must have expanded research effort consistent with their great expansion of use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, physiologists, pathologists, and horticulturists carrying on both basic and applied research on many problems concerned with production of floricultural and other ornamental plants. Breeding and genetics are being done at Beltsville, Md., Cheyenne, Wyo., The National Arboretum, Washington, D. C., at Tifton, Ga., in cooperation with the Georgia Coastal Plain Experiment Station, and at Morgantown, W. Va., in cooperation with the West Virginia Agricultural Experiment Station. Research on diseases is conducted at Beltsville, Md., and cooperative with the Georgia Coastal Plain Experiment Station, and the Agricultural Experiment Stations of Oregon, Washington, and West Virginia. Experiments for improving cultural methods and growth regulation are carried on at Beltsville, Md., and in cooperation with the above Experiment Stations.

Reference collections of living plants and herbarium specimens are maintained at the National Arboretum. Promising selections from foreign introductions received through the New Crops Research Branch are propagated at the Arboretum for testing and for distribution to other botanic gardens, arboreta, and experiment stations. Plant specimens are identified and classified.



Cooperative agreements are in effect with (1) the West Virginia Agricultural Experiment Station, Morgantown, W. Va., on the breeding and genetics of lilies and on the screening of native woody plants of the Appalachian area for potential value as ornamentals, and (2) Oregon State University on lily virus studies.

A grant to Oregon State University provides for study of the mode of action of hydrazine as a physiological regulator of the growth of ornamentals.

Crown-gall tumor of roses is being investigated in India.

The Federal scientific effort now devoted to this area totals 22.7 scientist man-years divided as follows: Breeding and genetics 11.3; diseases 4.0; culture and physiology 4.0; and systematic biology 3.4.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 160 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

1. African violets. Genetic and chromatographic analyses of the inheritance of a red leaf pigment of Saintpaulia diplotricha show that an anthocyanin pigment in this species is controlled by a dominant gene. A survey of large numbers of interspecific hybrids showing this red-leaf character indicates possibility of a lethal condition when the plant is homozygous for dominant gene.

2. Azaleas. Further progeny of deciduous x evergreen hybrids have had considerable yellow pigment in their flowers but fertility has not improved. A new dwarf azalea, My-O, has been registered and released to nurserymen. A unique feature is a stable variegated leaf pattern. Colchicine treatment of several varieties has yielded affected sectors which are being selected and propagated.

3. Carnations. Tetraploid carnations are being increased for trial at Cheyenne, Wyo. Some are completely tetraploid and others are of the 2-4-4 type. The hardy dianthus-type 'Cheyenne' is tetraploid and crosses readily with 2-4-4 chimeras and 4-4-4 types. Resulting seedlings are all tetraploid.

4. Chrysanthemums. At Cheyenne, Wyo., 15 seedlings of hardy chrysanthemums were selected for increase and further trial. Seven new hardy varieties were released jointly with the Montana Agricultural Experiment Station.

5. Crape myrtle. Hybridization has been primarily involved with Lagerstroemia indica crossed with L. faurei and L. subcostata, which are resistant to mildew. Of a total of 69 crosses, utilizing 22 different species and cultivars as female parent and 9 different species and cultivars as male parent, 50 have produced seed. Chromosome counts ( $2n = 48$ ) have been obtained for L. faurei, L. subcostata, and seven cultivars of L. indica. The chromosome count of Lawsonia inermis, a related fragrant plant, was determined to be  $2n = 34$ .

6. Cytoplasmic inheritance. New mutant cytoplasmic factors were discovered in geranium, cineraria, yew, rose, poinsettia, and several other ornamentals. Additional examples have been collected from other sources. These "marker genes" are being used to study the developmental morphology of several ornamental plants.

7. Daylilies. Three new tetraploids of well known cultivars were induced by colchicine treatment and confirmed cytologically. The tetraploids, 'tetra Alan', 'tetra Nashville', and 'tetra Jade Crest' all showed more substance, larger size, and better color than the comparable diploids. Large numbers of seedlings were obtained from induced tetraploids of the cultivars, 'Sherwood', 'Chetco', and 'Queen of Gonzales'.

8. Hibiscus. Several growth regulator substances have been used with little success in an attempt to promote seed production from inter-specific crosses. Preliminary study indicates that injection of pollen into the ovary may facilitate future hybridization. Of the 247 crosses made, 71 have produced seed and a seedling population of 3,000. H. rosa-sinensis 'Vulcan' has been named after trial under outdoor conditions in Florida and California. 'Vulcan' resulted from a cross of H. rosa-sinensis 'Fire Chief' x H. rosa-sinensis 'Mason Red'. The plant has distinct glossy, leathery foliage and a flower that is a brilliant red color with gold reverse and is of excellent form and substance.

9. Holly. Major emphasis is currently placed on selection, propagation, and testing of hybrid clones produced during the last 11 years. Cooperative holly test areas have been established in Lafayette, La., Pine Mountain, Ga., and Norfolk, Va. This year additional test areas are planned in Oak Ridge, Tenn., Wooster, Ohio, and Aurora, Ore. This testing program will be expanded only to those areas which show an active interest in holly evaluation. Ilex crenata 'High Light' was officially released.

10. Lilies. (a) Polyploids. The best tetraploid Lilium longiflorum lily clones were forced following various preplanting treatments. Included were the 4 clones already released and 15 others for comparison. Several new clones were selected for increase. Several clones of L. speciosum album x L. auratum have been selected and are being increased for introduction.



(b) Cytology. The 48 chromosomes of the amphidiploid L. speciosum x L. henryi formed a high frequency of 24 bivalents and will probably prove to be fertile. The diploid hybrid has very irregular meiosis and was self-sterile.

(c) Endosperm breakdown in Lilium speciosum x L. auratum hybrid. The early divisions of the pentaploid endosperm were very regular. At about 12 to 15 days following pollination the endosperm began to show irregularities in mitosis. Some nuclei fused to form very large nuclear bodies, others developed irregular shapes. This situation occurred only when L. speciosum was the maternal parent. The reciprocal cross formed a normal endosperm. The only difference was that when L. speciosum was the seed parent the endosperm contained four sets of L. speciosum chromosomes and one of L. auratum. The reciprocal cross had four sets of chromosomes from L. auratum and one from L. speciosum.

(d) Backcross populations derived from pollen of (Lilium speciosum x L. henryi) x L. speciosum are now flowering and this population should give rise to a new group of lilies.

11. Magnolia. Six interspecific hybrids from a population of Magnolia liliflora 'Nigra' x M. stellata 'Rosea', and one from a population of M. x 'Reflorescens' x M. stellata 'Waterlily' were selected for propagation and further testing. A few plants from a vigorous, tree-type of magnolia flowered this spring at the early age of 7 years from seed. This is an interspecific hybrid M. x 'Veitchii' x M. denudata with flower color segregations of white, blush-pink, and pink.

12. Poinsettia. After extensive trial, four new cultivars of poinsettia were released to the trade; a red, called 'Stoplight' and 3 whites, called 'Snowflake', 'Snowcap', and 'White Cloud'. The cytoplasmic genetic system of poinsettia has been extensively studied and described in publications. Additional seedlings have been sent out for trial, and further crosses aimed toward seed propagation of commercial varieties were made.

13. Pyracantha. A cytological study of Pyracantha was initiated to determine possible chromosome variability within the genus. Determinations have been completed for 34 species and cultivars, all of which had chromosome complements of  $2n = 34$ . Named 'Shawnee', a seedling of the variety San Jose was selected for its abundant, glossy, clear yellow to light orange fruits; foliage that is semi-persistent; dense branching, and resistance to fire blight and scab. During the year three Pyracantha cultivars have been registered. Work is nearing completion on the cultivars checklist. The checklist now includes 930 names, which will be published with references and brief descriptions.

14. Roses. (a) Tetraploid rose. A colchicine-treated multiflora rose originally 2x, was determined to be 4x by cytological examination of stomates, pollen size, and chromosome counts.

(b) Seed germination. Seed from over-wintering Rosa nutkana achenes required low temperature after-ripening for germination.

15. Viburnum. Limited hybridization between the evergreen species, V. utile and V. davidi, and select deciduous cultivars, has been initiated. Two V. carlesii type seedling selections have been named 'Cayuga' and 'Mohawk'. 'Cayuga' (V. carlesii x V. carlcephalum) is distinct in producing abundant inflorescences of pink buds which open to white flowers in late April; compact growth habit; and medium textured foliage with tolerance to bacterial leaf spot and powdery mildew. 'Mohawk' (V. x burkwoodii x V. carlesii) may be distinguished from related cultivars by dark red buds that open to white flowers with red blotched reverse; abundant inflorescences; strong, spicy clove fragrance; compact growth habit; and foliage resistant to bacterial leaf spot and mildew. Chromosome counts have been completed for seven additional accessions which represent four species and three hybrids. A total of 1,660 names, representing species and cultivars, have been indexed for an international checklist of cultivar names.

16. Woody ornamentals. At Cheyenne, Wyo., species of dogwood and cotoneaster were procured and crosses made among the cotoneaster. Experiments to induce juvenile flowering of Philadelphus and Picea pungens were not successful.

17. Herbarium collections. Over 3,000 herbarium specimens were prepared from plants growing in the Juan Fernandez Islands. Work is underway towards a taxonomic revision of the eastern Asiatic species of viburnum.

## B. Diseases

1. Camellia. Camellia plants grown in several soil mixtures with and without soil infestation with Phytophthora cinnamomi showed little difference in growth.

2. Chrysanthemum (a) Stunt virus. Local starch lesions of chrysanthemum stunt virus can be detected on inoculated leaves of florists' cineraria, Senecio cruentus, 15 to 20 days after inoculation. Light and temperature conditions for seedling development and maturity of the plant are important factors which influence host susceptibility.

(b) Tomato and chrysanthemum aspermy viruses. A serological relationship was established between the Blencowe isolate of the aspermy virus from tomato, CMV-Y and CMV Imperial Strain 78. Three isolates of the aspermy virus from chrysanthemum including a Dutch, California, and Beltsville



isolate were serologically related to the Blencowe isolate but not to the two strains of CMV. The Blencowe isolate showed a closer serological relationship to CMV-Y than to the chrysanthemum aspermy viruses.

3. Rose. Blackspot. Inocula from seven geographical areas showed inoculum from Northern States to be most virulent. Inoculations at monthly intervals indicated that the rose plants varied in susceptibility through seasonal cycles.

### C. Culture and Physiology

1. Pigments - Anthocyanins. Cyanidin 3-arabinoside-5-glucoside, the first representative of this glycosidic class was isolated and identified from flowers of azalea (Rhododendron spp) cv. 'Red Wing'. Other anthocyanins present were cyanidin-3-glucoside, cyanidin-3-galactoside, cyanidin 3-arabinoside, and cyanidin 3,5-diglucoside.

The structural modification of red anthocyanins to yield relatively stable violet and blue colors was studied with the cooperation of the Western Utilization Research and Development Division. The results of this study help clarify and explain mauve, violet, and blue pigments in plants. The blue pigment from Centaurea cyanus cv. 'Blue Boy' has been isolated and crystallized. The anthocyanin has been identified as cyanidin 3,5-diglucoside and the co-pigment as a flavone glucoside which contains two aglycones. One aglycone has been identified as 7-O-Me-apigenin (Genkwanin) and the other appears to be a 7-O-Me-vitexin. The co-pigment appears to be present as a bi-flavonyl.

2. Flowering of hydrangeas accelerated with growth regulating chemicals. Dormant hydrangea plants with flower buds that were exposed to atmospheres of 10, 50, and 100 ppm of ethylene for 5 days bloomed sooner than plants without ethylene when they received no dormancy-breaking cool storage or only one-half their optimum storage. Stem length and flower size were affected more by application of gibberellic acid than by ethylene.

3. Iris flowering affected by air temperatures. Flowering of bulbous iris was accelerated by exposure of the bulbs to a temperature of 65°F for 1 and 2 weeks after they had been vernalized at 50° preparatory to forcing. Bulbs retarded by temperatures of 80-85° for later blooming were also accelerated by use of 65° after vernalization at 50°. This treatment caused a marked reduction in leaf length of plants of the Blue Ribbon cultivar where the excessive foliage normally produced is undesirable. (In cooperation with the Western Washington Experiment Station, Puyallup, Washington.)

4. Greenhouse azaleas pruned chemically. Growing points of azalea shoot tips can be selectively inhibited or killed by foliar applications of aqueous emulsions of the lower alkyl esters of C<sub>8</sub> to C<sub>12</sub> fatty acids and C<sub>8</sub> to C<sub>11</sub> fatty alcohols without damage to the rest of the plant. Axillary shoots develop on the sprayed plants at nearly the same time and usually in greater numbers than on manually pruned plants. These chemicals inhibited the terminal meristem without damaging the axillary meristems, foliage, and stems of a wide range of plants.

5. Easter lilies. Storage conditions for flowering and maintaining dormancy. Earliest blooming of Easter lilies from bulbs produced in the Pacific Northwest followed short storage (2-4 weeks) at 35-50°F followed by exposure to fluctuating temperatures in a coldframe prior to forcing. Storage life of the bulbs was extended by an initial period at 70° followed by 35° alternated with short periods at 70°.

6. Abortion of flower buds in chrysanthemum after application of naphthalene-base oils. Application of the naphthalene-base oil, HAN (Heavy aromatic naphtha) caused abortion of partially initiated flower buds in chrysanthemum (*Chrysanthemum morifolium* Ramat. cv. 'Fred Shoesmith'). The response depended on the stage and rate of flower initiation, the cultivar treated, and the surfactant used to emulsify the oil. Treatment of vegetative plants caused death of the apical meristems. Treatment when the terminal flower bud had completed flower initiation, but before the lateral flower buds had initiated all of the florets, caused the abortion only of the lateral flower buds. The terminal flower bud was unaffected and developed at the same rate as terminal flower buds grown with the lateral buds removed manually. Treatment of plants with the flowers initiated was ineffective. Chrysanthemum cultivars other than 'Fred Shoesmith' were less responsive to treatments with HAN.

7. Temperature tolerances and light requirements for the germination of annual, pot plant, and herb seeds. Seeds of 113 species were separated into 9 types on the basis of their responses to temperature (50-95°F) and light (continuous cool white fluorescent illuminance) namely: 1) tolerant to temperature and light, 2) high temperature inhibited, 3) low temperature inhibited, 4) restricted temperature, 5) light required at temperatures tested, 7) light required only at high temperature, 8) light inhibited at temperatures tested, and 9) light inhibited only at high temperatures. Temperatures below 65° inhibited formation of chlorophyll in the seedlings; emergence of the seedlings was very irregular. Temperatures above 75° often caused development of seedlings with water-soaked radicles.

8. Azaleas. Azalea plants grown in a shaded house, 53% light, 31% light, or with 10-hour days gave similar results when cooled and forced in the greenhouse for early bloom. Four-week cooling at 50° did not result in as satisfactory bloom as 6 weeks, and 6 weeks was not as good as 8-weeks cooling.



In an attempt to delay blooming time, azalea flower opening was not affected by late sprays (1 to 2 weeks before normal bloom) of either dichobenil, B-dimethylamino succinamic acid, 2-chloroethyltrimethyl ammonium chloride or CIPC and CIPC related compounds.

9. Camellia. Gibberellic acid (11,500 ppm) hastened opening of camellia flowers and produced larger flowers. Dimethylsulfoxide alone had no effect on flowers. Used with gibberellic acid, DMSO gave no additive effect and wounding was still required for sufficient absorption of gibberellic acid.

10. Lilies. (a) Lily field production. Plots to which ureaform was applied before planting in October produced more flowers than those not fertilized until March or those fertilized at planting with nitrate of soda. No cultivation in the field gave slightly higher bulb yields than those given the usual two cultivations (March and May).

(b) Lily forcing. Six-inch pots for forcing 5- to 6-inch bulbs gave more flowers than 5-inch pots. Addition of ureaform or additional phosphorus increased the number of buds.

Lots of bulbs potted and plunged outside until forced December 30, January 14, or February 1, received 483, 526, and 928 hours of temperature 50°F and below, respectively at the 3 forcing dates. Other lots of bulbs potted and placed in a coldframe received 192, 257, and 595 hours of 50° and below, respectively by the 3 forcing dates. All plants required the same forcing time to bloom but those from the coldframe were taller, possibly because of additional shade before forcing.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Breeding and Genetics

Arisumi, Toru. 1965. Screening diploid and tetraploid progenies of day-lilies by stomatal size. Proc. ASHS 87: 479-485.

Arisumi, Toru. 1965. The African violet species. Amer. Hort. Mag. 44 (3): 154-164.

Emsweller, S. L. and Joseph Uhring. 1965. Some suggestions in lily breeding. North Amer. Lily Soc. Yrbk. 20-26.

Emsweller, S. L. 1965. Do mixed pollens aid in wide hybridization? Royal Hort. Soc. Lily Yrbk. 48-51.

Emsweller, S. L. and Joseph Uhring. 1965. Lilium x 'Black Beauty' - Diploid and amphidiploid. Royal Hort. Soc. Lily Yrbk. 45-47.

Egolf, D. R. 1966. Major pyracantha research underway at U.S. National Arboretum. Amer. Nurseryman 123 (2): 58, 60.

Egolf, D. R. 1966. Two new cultivars of viburnum: 'Cayuga' and 'Mohawk' (Caprifoliaceae). Bailey 14 (1): 24-28.

Nimoto, D. H. 1966. Chromosome numbers of some hibiscus species and other malvaceae, Bailey 14 (1): 29-34.

Uhring, Joseph. 1966. Lily research at Beltsville. North Amer. Lily Soc. Yrbk. 7-20.

### Diseases

Lawson, R. H. and P. J. Taconis. 1965. Transfer of dahlia mosaic virus with liquid nitrogen and relation of transfer to symptoms and inclusions. *Phytopathology* 55 (7): 715-718.

Lawson, R. H. 1966. Oakleaf chlorosis symptomatic of cucumber mosaic virus infection in dahlia. *Phytopathology* 56 (3): 343-344.

### Culture and Physiology

Asen, Sam. 1965. Preparative thin-layer chromatography of anthocyanins. *J. Chromatography* 18: 602-603.

Cathey, H. M., J. Halperin, and A. A. Piringer. 1965. Relation of dimethylamino succinamic acid to photoperiod, kind of supplemental light, and night temperature on growth and flowering of garden annuals. *Hort. Res.* 5 (1): 1-12.

Cathey, H. M. 1965. Initiation and flowering of rhododendron following regulation by light and growth retardants. *Proc. ASHS* 86: 753-760.

Cathey, H. M. 1965. Growth regulators, past and predicted. *N.Y. State Flower Growers Bull.* Oct.

Cathey, H. M., A. G. Yeomans and F. F. Smith. 1966. Abortion of flower buds in chrysanthemums after application of a selected petroleum fraction of high aromatic content. *HortScience* 1 (2): 61-62.

Cathey, H. M. 1966. Houseplants. *Yrbk of Agric.* 1965. 275-278.

Cathey, H. M. 1965. Indoor garden for decorative plants. *USDA Misc. Pub.*

Gill, D. L. 1965. Camellia flowering response to some gibberellic acid bud treatments. *Amer. Camellia Yrbk.* 187-192.

Gill, D. L. and J. M. Good. 1965. Use of fumigants in Easter lily production. *Florists' Rev.* 136 (3524): 16-17, 58-59.

Gill, D. L. 1966. Pests among flowers. *Yrbk. of Agric.* 1965. 247-249.

Howard, Gene S. 1965. Herbaceous perennials for the Central Great Plains. *USDA Pub. ARS* 34-71. 10 pp.

Jefferson, R. M. 1966. Crabapples at the National Arboretum. *Amer. Hort. Mag.* 45 (2): 231-236.

Johnson, M. J. 1966. Basic points of landscaping. *Yrbk. of Agric.* 1965. 279-282.

Lane, H. C., H. M. Cathey, and L. T. Evans. 1965. The dependence of flowering in several long-day plants on the spectral composition of light extending the photoperiod. *Amer. J. Bot.* 52 (10): 1006-1014.

Mazzeo, P. M. 1965. Further notes on Shenandoah National Park plants. *Castanea* 30: 191-205.

Meyer, F. G. 1965. Belgium--Some features of its horticulture and gardens. *Amer. Hort. Mag.* 44 (4): 234-237.

Meyer, F. G. 1965. Notes on wild Coffea arabica from southwestern Ethiopia, with some historical considerations. *Econ. Bot.* 19 (2): 136-151.



- Meyer, F. G. 1965. New species of valeriana from Colombia, Ecuador, and Peru. *Brittonia* 17 (2): 112-120.
- Meyer, F. G. 1966. Narcissus species and wild hybrids. *Amer. Hort. Mag.* 45 (1): 47-76.
- Ohwi, J. 1965. *Flora of Japan* (English edition) edited by F. G. Meyer and E. H. Walker. Pub. Smithsonian Institution. August.
- Semeniuk, Peter and R. N. Stewart. 1965. The effect of time of changes in levels of nitrogen, phosphorus and potassium on seed production and germination of Matthiola incana. *Proc. ASHS* 86: 695-700.
- Skinner, H. T. 1966. Plants for shade; plants for sun. *Yrbk. of Agriculture* 1965. 249-253.
- Skinner, H. T. 1965. Selection and determination of ornamental tree cultivars. *Proc. Soc. of Municipal Arborists* 1 (1): 40, 66-74.
- Stewart, R. N. and Peter Semeniuk. 1965. The effect of interaction of temperature with afterripening requirement and compensating temperature on germination of seed of five species of Rosa. *Amer. J. Bot.* 52 (7): 755-760.
- Stewart, Robert N. 1965. The origin and transmission of a series of plastogene mutants in Dianthus and Euphorbia. *Genetics* 52 (5): 925-947.
- Stuart, Neil W., C. J. Gould, and Sam Asen. 1966. Accelerated flowering of bulbous iris following exposure to ethylene. *HortScience* 1 (1): 19-20.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Barker, P. A., G. A. Baker, and R. V. Stephens. 1965. First-year performance of Schinus polygamus in the landscape tree evaluation program of California. *Proc. ASHS* 87: 551-556. (Calif.)
- Boodley, J. W. and M. Meyer, Jr. 1965. The nutrient content of Bonnaffon Deluxe chrysanthemums from juvenile to mature growth. *Proc. ASHS* 87: 472-478. (N. Y.)
- Bradley, G. A. and D. Smittle. 1965. Media pH and extractable Fe, Al, and Mn in relation to growth of Ericaceous plants. *Proc. ASHS* 87: 486-493. (Ark.)
- Carpenter, E. D. and D. P. Watson. 1965. The initiation and differentiation of flower buds of four Rosaceous ornamental shrubs. *Proc. ASHS* 86: 806-808. (Mich.)
- Durkin, D. J. 1965. Bud dormancy in the Better Times rose. *Proc. ASHS* 86: 798-805. (Ind.)
- Gilbart, D. A. and R. R. Dedolph. 1965. Phytokinin effects on respiration and photosynthesis in roses and broccoli. *Proc. ASHS* 86: 774-778. (Mich.)
- Hanan, J. J. 1965. Efficiency and effect of irrigation regimes on growth and flowering of snapdragons. *Proc. ASHS* 86: 681-692. (N.Y.)
- Havis, J. R. 1965. Desiccation as a factor in winter injury of rhododendron. *Proc. ASHS* 86: 764-769. (Mass.)
- Hogan, L. and J. B. Shanks. 1965. Nutritional studies on Philodendron cordatum. *Proc. ASHS* 86: 662-671. (Md.)

- Kelley, J. D. and R. W. Shier. 1965. Seasonal changes in the macro-nutrient composition of leaves and stems of Taxus media. Proc. ASHS 86: 809-814. (Ky.)
- Kelley, J. D. and R. W. Shier. 1965. Seasonal changes in the micro-nutrient composition of leaves and stems of Taxus media. Proc. ASHS 87: 545-550. (Ky.)
- Kofranek, A. M. and W. P. Hackett. 1965. The influence of daylength and night temperature on the flowering of poinsettia, cultivar 'Paul Mikkelsen'. Proc. ASHS 87: 515-520. (Calif.)
- Larsen, F. E. and J. F. Scholes. 1965. Effects of sucrose, 8-hydroxy-quinoline citrate and N-dimethyl amino succinamic acid on vase-life and quality of cut carnation. Proc. ASHS 87: 458-463. (Wash.)
- Li, P. H., C. J. Weiser, and R. van Huystee. 1965. Changes in metabolites of Red-Osier dogwood during cold acclimation. Proc. ASHS 86: 723-729. (Minn.)
- Lindstrom, R. S. 1965. Carbon dioxide and its effect on the growth of roses. Proc. ASHS 87: 521-524. (Mich.)
- Mastalerz, J. W. 1965. Bud blasting in Lilium longiflorum. Proc. ASHS 87: 502-509. (Penna.)
- Mastalerz, J. W. 1965. The effect of gibberellic acid on the flowering shoots of Better Times roses. Proc. ASHS 87: 525-530. (Penna.)
- Meyer, M. M. and H. B. Tukey. 1965. Nitrogen, phosphorus, and potassium plant reserves and the spring growth of Taxus and Forsythia. Proc. ASHS 87: 537-544. (N.Y.)
- McQuire, J. J., J. T. Kitchin and R. Davidson. 1965. The effect of different growth retardants on the growth and flowering of Rhododendron obtusum 'Hinodegiri'. Proc. ASHS 86: 761-763. (R.I.)
- Nelson, P. V. and J. W. Boodley. 1965. Development of a set of standard leaf composition values for carnation. Proc. ASHS 86: 641-649. (N.Y.)
- Nelson, P.V. and J. W. Boodley. 1965. An error involved in the preparation of plant tissue for analysis. Proc. ASHS 86: 712-716. (N.Y.)
- New, E. H. 1965. Influence of time of pollination on seed set in certain Zantedeschia. Proc. ASHS 86: 708-711. (Mich.)
- Odom, R. E. and W. J. Carpenter. 1965. The relationship between endogenous indole auxins and the rooting of herbaceous cuttings. Proc. ASHS 87: 494-501. (Kans.)
- O'Rourke, F.L.S., and R. R. Dedolph. 1965. Comparative efficacy of two rooting compounds and different media for root induction with greenwood cuttings of seven species. Proc. ASHS 86: 815-817. (Mich.)
- Pokorny, F. A. 1965. An evaluation of various equipment and media used for mist propagation and their relative cost. Ga. Exp. Sta. Bull. 139. (Ga.)
- Pokorny, F. A. and J. R. Kamp. 1965. Influence of photoperiod on the rooting response of cuttings of carnation. Proc. ASHS 86: 626-630. (Ill.)
- Pope, T. E. and B. L. Baum. 1965. Effects of cooling method and phosfon on Lilium longiflorum 'Georgia'. Proc. ASHS 87: 510-514. (La.)



- Rennix, M. T., C. Y. Hu, A. P. Dye, and O. M. Neal. 1965. Increase in flower number and decrease in regrowth of azaleas induced by foliar application of the retardants B-Nine and Cycocel. W. Va. Acad. Sci. 37: 109-115. (W. Va.)
- Schneider, E. F. 1965. Survival of rooted cuttings of three woody plant species after low temperature storage. Proc. ASHS 87: 557-562. (N. J.)
- Schneider, E. F. 1965. Changes in free amino acids in the leaves of Ilex crenata nigra during hardening off and storage at low temperatures. Proc. ASHS 86: 731-740. (N. J.)
- Schmalfeld, H. W. and R. L. Carolus. 1965. Nutrient redistribution in the tulip. Proc. ASHS 86: 701-707. (Mich.)
- Seeley, J. G. and A. H. Weise. 1965. Photoperiodic responses of garden and greenhouse chrysanthemums. Proc. ASHS 87: 464-471. (Penna.)
- Seeley, J. G. 1965. Soil temperature and the growth of greenhouse snapdragons. Proc. ASHS 86: 693-694. (Penna.)
- Seeley, J. G. and J. R. Steiner. 1965. Soil temperature and the growth of greenhouse carnations. Proc. ASHS 86: 631-640. (Penna.)
- Tayama, H. K. and R. O. Miller. 1965. Relationship of plant age and net assimilation rate to optimum growing temperature of the snapdragon. Proc. ASHS 86: 672-680. (Ohio)
- Tinga, J. H. 1965. The effect of gases on rooting of carnations. Proc. ASHS 87: 453-457. (Va.)
- Waters, W. E. 1965. Influence of nutrition on flower production, keeping quality, disease susceptibility, and chemical composition of Chrysanthemum morifolium. Proc. ASHS 86: 650-655. (Fla.)
- Wittsell, L. E. and W. J. Carpenter. 1965. Soil compaction effects on chrysanthemums and snapdragons. Proc. ASHS 87: 531-536. (Kans.)
- Manning, W. J. 1965. Factors affecting sporangial production in Phytophthora cinnamomi. Phytopathology 55: 505. (Del.)

SHADE, ORNAMENTAL AND WINDBREAK TREE BREEDING,  
DISEASES AND CULTURE

Crops Research Division, ARS

Problem. Our expanding population has created among home owners, park executives, arborists, and highway engineers urgent need of climatically-adapted and disease-resistant trees and shrubs for use in beautification and programs designed to improve living conditions. Costs of maintenance and replanting programs increase yearly for home owners and cities because of epidemic diseases. Research to develop more efficient and less costly disease control methods is needed. Causes of some diseases are still to be determined. Establishment of trees and shrubs is difficult in the severe climate of the Northern Great Plains and high mountain plateaus. Studies of ways to ensure survival of newly-planted trees and shrubs in these difficult regions are needed. There is also need to determine the effects of windbreak plantings on reduction of wind velocity, snow dispersal and retention, and on crop responses.

USDA AND COOPERATIVE PROGRAM

In Department research, special attention is given at Beltsville, Md., and Delaware, Ohio, to the search for chemical cures for trees affected with Dutch elm disease, and at Beltsville, Md., and Tifton, Ga., to controls for mimosa wilt. Limited, but important research, on diseases of live oak, especially live oak canker, and blight of sweet gum is done at Beltsville. At Beltsville, additional basic research is conducted to determine the nature of many other tree diseases of unknown cause. At Mandan, N. D., research is concerned with effects of windbreaks on crop yields, spread of snowfall, and soil erosion. The culture and handling of shade trees and windbreak studies on culture and effect on crop yields are carried on at Cheyenne, Wyo. Research on shade tree diseases is conducted at Delaware, Ohio, in cooperation with the Ohio Agricultural Experiment Station. At Tucson, Ariz., in cooperation with the Arizona Agricultural Experiment Station and the National Park Service, research is in progress on deterioration of the saguaro cactus at the Saguaro National Monument.

Research is being conducted under a contract with the College of Agriculture, University of the Philippines on the host range and transmission of the cadang-cadang disease of coconut palm.

The Federal scientific effort now devoted to this area totals 8.2 scientist man-years divided as follows: Breeding 0.5, diseases 4.7, and culture 3.0.

PROGRAM OF STATE EXPERIMENT STATIONS

Current research at State Agricultural Experiment Stations amounts to 20 scientist man-years.



## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Breeding

1. Elm. A tetraploid Ulmus pumila was produced by treatment of very young seedlings with colchicine. U. pumila is highly resistant to Dutch elm disease. It has 28 chromosomes and U. americana has 56. Despite thousands of attempts to hybridize the two species, no hybrids have been produced over a 25-year period. The new tetraploid U. pumila may cross with U. americana.

2. Mimosa. Selections for wilt resistance were made from a large stand of mimosa seedlings planted in Georgia in soil heavily invaded by Fusarium perniciosum, the cause of mimosa wilt. Flowers of the selections range from dark red to almost white. The selections are being increased. (Cooperative with the Georgia Agricultural Experiment Station.)

### B. Diseases

1. Elm. In tests of systemic fungicides for control of Dutch elm disease, Captan in dimethylsulfoxide, applied as a wet bandage to trunks of 2- to 3-inch caliper, reduced severity of disease in inoculated trees. Other fungicides were less effective. Additional, expanded field experiments with Captan are planned for 1966. Colloidal iodine injected into trunks of elm failed to control the disease. In both disease-susceptible and disease-resistant species of 2-year-old elm seedlings, transpiration increased about 10% during the week after inoculation with Ceratocystis ulmi. But by the second week, transpiration decreased rapidly in American elm as wilting progressed. In U. pumila (resistant) transpiration rate declined only slightly during a 4-week period and rose afterward to approximately that of uninoculated checks. Healthy U. pumila consistently lost less water than healthy U. americana under comparable conditions. (Cooperative with the Ohio Agricultural Experiment Station.)

2. Sweet gum. No evidence was obtained that dying of sweet gum in the Washington, D. C. area is infectious. No pathogens were isolated and no symptoms of disease developed in trees budded or grafted with typically symptomatic material from affected trees. Some trees previously diseased have recovered. Negative evidence from inoculation, budding and grafting experiments suggests an environmental complex may have caused the extensive dying observed 10 to 20 years ago. No extensive dying of sweet gum has been observed in recent years.

3. Saguaro. In cooperation with the University of Arizona and the National Park Service, studies were continued of saguaro mortality in the Saguaro National Monument. The bacterium Erwinia carnegieana, that causes the wet rot, can survive in either wet or dry soil stored at 60, 55, and 45°C for 1, 2, and 3 weeks, respectively. Viable bacteria were recovered after 5 weeks from similarly treated soils stored at temperatures ranging from 45° to 5°. However, even at concentrations of 10<sup>8</sup>

cells/ml E. carnegieana did not cause disease in plants held at 5°. In contrast, as few as  $10^5$  cells/ml caused disease when injected into saguaros held at 45°. Seedlings with injured roots became infected when transplanted into soils infested with suspensions containing  $10^5$  ml or more cells of E. carnegieana. Further, when saguaro seeds were allowed to germinate on soils infested with suspensions containing  $10^1$  or more cells/ml of E. carnegieana, approximately 40% of the resulting seedlings became infected.

Bacteria pathogenic to saguaro cacti were recovered from saguaro flower buds, flowers, and postblooms on branches of plants in the desert. Pathogenic bacteria were also recovered from the gut and surface of larvae of Cactobrosis fernaldialis and Carpophylus longiventris. Tomato (but not saguaro) soft-rotting bacteria were also recovered from the larvae of second and third generation, laboratory-reared C. fernaldialis.

The mortality of plants in 60 acres (6 x 10 acre plots) at Saguaro National Monument from bacterial necrosis amounted to 7.05%--the greatest loss in a single year since at least 1955.

4. Coconut palm. Study of cadang-cadang of coconut palm was continued in the Philippines on PL-480 funds. Positive proof of virus causation was not obtained. Several species of weeds did not develop virus symptoms after inoculation with juice from affected palms. A virus still seems to be the most probable cause of cadang-cadang. This project is scheduled to terminate at end of December 1966.

### C. Culture

1. Materials, production and management of farmstead windbreaks. Farmstead windbreaks that have proven highly effective for protection purposes in past years were ineffective against the March 2-5, 1966, blizzard. Snow blown through the belts drifted 10 to 20 feet deep against farm buildings and in livestock areas. Drifts created a reverse wind action on their lee sides that drifted snow into livestock shelters having south openings. These infrequent blizzards require a series of windbreaks to prevent clogging of farmsteads and feed lots. Belt orientation is also important during prolonged blizzards. The NNE to NNW winds created drifts 2 to 4 feet deep and 300 feet wide on the lee side of east-west belts and drifts 15 to 20 feet deep and 30 to 40 feet wide on the lee side of north-south belts. Comparisons were made on quarters and sections where species and densities were identical. Six new selections were made and propagated for further testing of hardy columnar hybrid Siberian elm.

2. Crop plant response to field windbreaks (shelterbelts). We have shown that bottom density of field windbreaks is an important factor in the distribution of snow on crop land which can greatly influence yields. Wheat



yields on either side of two artificial barriers having densities of 14% and 21% in the bottom 1/3 and the top 2/3 were identical, although over-winter soil moisture buildup to depths of 6 feet was much greater and over a wider area on the lee side of the barrier having the lower density.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Diseases

- Roberts, Bruce R. 1965. The effect of chilling and photoperiod on bud break. Jour. Forestry 63 (3): 180-181.
- Roberts, Bruce R. 1966. Transpiration of elm seedlings as influenced by inoculation with Ceratocystis ulmi. Forest Science 12 (1): 44-47.
- Schreiber, Lawrence R. 1966. An inoculation technique using nylon mesh. Plant Dis. Reprtr. 50 (2): 122-123.

##### Culture

- George, E. J. 1965. Methods of improving conifer survivals. USDA Forest Service, Tree Planters Notes No. 71.
- Howard, Gene S. 1965. Herbaceous perennials for the Central Great Plains. ARS 34-71. 10 pp.
- Johnson, E. W. 1966. Ornamental and windbreak trees for the Southern Great Plains. ARS 34-77. 52 pp.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

- Neal, O. M., A. P. Dye, R. E. Amos, Jr., and M. T. Rennix. 1963. A method for studying root regeneration in cuttings. W. Va. Acad. Sci. 35: 66-71. (W. Va.)
- Orton, Elwin R. 1965. Hybridization of American and English holly. Holly Soc. Amer. Proc. 39: 1-3. (N. J.)
- Wilson, C. L. 1965. Ceratocystis ulmi in elm wood. Phytopathology 55: 477 (Ark.)
- Wilson, C. L. 1965. Consideration of the use of persimmon wilt as a silvicide for weed persimmons. Plant Dis. Reprtr. 49: 789-791. (Ark.)
- Hildebrand, D. C. and M. N. Schroth. 1965. Erwinia acorn drop of Quercus, a new disease. Phytopathology 55: 1061. (Calif.)
- Edgington, L. V. 1965. Nature of wilt resistance induced by growth regulators. Phytopathology 55: 1056. (Conn.)
- Holmes, F. W. 1965. Virulence in Ceratocystis ulmi. The Netherlands Jour. Plant Pathology (Tijdschrift over Plantenziekten) 71: 97-112. (Mass.)
- McKenzie, M. A. 1965. Natural infection of Buisman elm by Ceratocystis ulmi. Phytopathology 55 (2): 130. (Mass.)
- Holmes, F. W. 1965. Effects on street trees of the use of salt as a snow control chemical. N.J. Fed. of Shade Tree Comm. Ann. Meet. Proc. 39: 38-45. (Mass.)

- Baker, J. H. 1965. Relationship between salt concentration in leaves and sap and the decline of sugar maples along roadsides. Mass. Agr. Exp. Sta. Bul. 553. 20 pp. (Mass.)
- Kelman, A. and G. V. Gooding, Jr. 1965. A root and stem rot of yellow-poplar caused by Cylindrocladium scoparium. Plant Dis. Reprtr. 49: 797-801. (N.C.)
- Kirk, T. K. and A. Kelman. 1965. Lignin degradation as related to the Phenoloxidasases of selected wood-decaying Basidiomycetes. Phytopathology 55: 739-745. (N.C.)
- Kinloch, B. B. and A. Kelman. 1965. Relative susceptibility to fusiform rust of progeny lines from rust-infected and noninfected loblolly pines. Plant Dis. Reprtr. 49: 872-874. (N.C.)
- Cowling, E. C. and W. Merrill. 1965. Amount and distribution of nitrogen in wood-destroying fungi. Phytopathology 55: 1054. (N.C.)
- Merrill, W. and E. B. Cowling. 1965. Effect of variation in nitrogen content of wood on rate of decay. Phytopathology 55: 1067. (N.C.)
- Skelly, J. M., F. A. Wood, and F. W. Cobb. 1965. Inoculation of one-year-old twigs of red oaks with Ceratocystis fagacearum. Phytopathology 55: 131 (Pa.)
- Cobb, F. W., F. A. Wood, and R. A. Schmidt. 1965. Occurrence of Ceratocystis fagacearum in wounds on red and chestnut oaks. Phytopathology 55: 179-182. (Pa.).
- Halliwell, R. S. 1965. Oak decline in Texas. Phytopathology 55: 1060. (Texas)
- Houston, D. R., C. R. Drake, and J. E. Kuntz. 1965. Effects of environment on oak wilt development. Phytopathology 55: 1114-1121. (Wisc.)
- Phelps, W. R. and J. E. Kuntz. 1965. Translocation and persistence of cycloheximide and oligomycin in Northern pin oaks. Forest Science 11: 354-359. (Wisc.)



## REPLACEMENT CROP INTRODUCTION AND EVALUATION

Crops Research Division, ARS

Problem: American agriculture is based on crops which have originated outside our continental limits. The improvement of existing crop varieties, the selection of new lines having high quality food proteins or natural resistance to insects and diseases, and the development of any number of other important characteristics are dependent on a continuous flow of introduced germ plasm. Inherent in this is the preliminary evaluation and cataloging of plant introductions for traits which will be of use to plant breeders and the agronomic development of potential crops as a result of joint botanical-utilization screening. These demands require the search for and introduction of 8 to 10 thousand plant collections and samples for analysis yearly. The perpetuation of valuable germ plasm through maintenance plantings and long-term seed storage is a necessary adjunct of this program of research.

### USDA AND COOPERATIVE PROGRAM

The nature of this program is to conduct investigations concerned with the introduction, evaluation, and maintenance of plant germ plasm for the development of a strong yet diversified agriculture for the United States. Both basic and applied research is undertaken in the areas of: assessment of the world's plant resources; search for diverse germ plasm in the world centers of crop origin, and exchange of improved types; evaluation of introductions as breeding stocks through a national cooperative program for sources of natural resistance to crop pests, as potential new crops, and for other uses brought about by shifts in agriculture; and the preservation of important segments of germ plasm either as seed or as vegetative stocks. Leadership for this program is at Beltsville, Maryland.

Four national introduction stations are responsible for evaluation, maintenance, and/or quarantine of new introductions which require special handling: Chico, California; Miami, Florida; Savannah, Georgia; and Glenn Dale, Maryland. The responsibility for preservation of seed stocks of national interest lies with the National Seed Storage Laboratory, Fort Collins, Colorado. Cooperative new crops studies to determine significant agronomic characteristics of plants having valuable end-products are conducted cooperatively with Experiment Stations of Montana, Nebraska, North Carolina, and Oregon. Four regional and one inter-regional introduction stations deal with the evaluation of crop breeding stocks essential to programs in State Experiment Stations.

Sixteen PL 480 projects are active, all dealing with research on the collection and evaluation of native plants of potential use in the agriculture of the United States. The countries and number of projects are as follows: Colombia - 1, India - 7, Israel - 2, Korea - 1, Pakistan - 1, Spain - 1, Turkey - 1, Uruguay - 1, Yugoslavia - 1.

The Federal scientific effort devoted to research in New Crops totals 38.5 scientist man-years. Of this number, 4.0 are devoted to international plant exchange, 4.4 to botanical investigations, 5.0 to special plant procurement and related botanical activities. Research on new crop evaluation includes 7.5 man-years for horticultural research, 3.8 for agronomic studies, 4.8 devoted to evaluation of potential new crops, 6.0 to pathology, and 3.0 to maintenance of germ plasm.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 18 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Plant Introduction

1. Breeding Stock Introduction. The international plant exchange program in 1965 yielded 6,694 introductions and 1,619 shipments were made to 108 countries. Cereals and Sorghums (1,664), Forages (1,409), and Oilseeds (1,012) constituted the major introductions.

a. International exchange. Major collections obtained through this medium included 120 legumes from Czechoslovakia.

b. Foreign exploration. Four direct explorations were completed in 1965. (1) Phase two of a major bean exploration in Central America and Mexico resulted in bringing the total collections to 1,300 local types of beans. These will contribute greatly to our diversity of germ plasm for breeding disease resistance. (2) In cooperation with Longwood Gardens, a collecting trip to northern India and Sikkim gave 189 species and types of hardy ornamentals.

c. Domestic exploration. Domestic exploration was at a minimum. A few token lots were added to the fruit project (S-9) and the Juniper project (NE-9). Five hundred potential ornamental and ground cover collections (NC-7) were reported but inventory records have not been completed. This project terminated June 30, 1966.

d. Maintenance of germ plasm. At the National Seed Storage Laboratory, approximately 9,000 accessions have been added to the collections reported for 1964, making a total of slightly over 43,000. Approximately 22,000 lots represent world collections.



Seeds received in good condition, with germination percentages ranging from 75% to 100%, have so far shown no evidence of loss of viability.

An effort has been made during the past year to locate genetic collections for permanent storage. This has not been very successful, but during the next year additional emphasis will be directed toward obtaining such collections. At the present time the only genetic stocks in storage are those for barley (Colorado) and a collection of tomato mutants.

## B. New Crop Evaluation

Evaluation of Breeding Stocks. Research emphasis is directed toward evaluation of germ plasm as sources of natural resistance to plant pests; determining characters which will enhance adaptation and crop versatility; and development of new varieties of agronomic, horticultural, and chemurgic crops at Federal introduction stations and through regional cooperative programs.

### 1. Horticultural Crops.

a. Fruits and nuts. The screening programs for desirable horticultural characters and for resistance to adverse environmental factors and diseases have been particularly active at the Chico, Glenn Dale, and Miami Plant Introduction Stations.

Emphasis at Chico continues on development of Actinidia chinensis as a new fruit crop for the mild temperate areas of the country. A seedling population has started to fruit and several have been selected for further study. The seed germination experiments showed that stratification at 40°F. followed by alternating temperatures gave the best germination.

One hundred pounds of fruit, believed to be the first commercial crop of Chinese gooseberries produced in this country, was sold last season in the San Francisco wholesale market. It brought 80¢ per pound. Propagation material for the planting came from the Chico station. Plantings totaling 27 acres are at various stages of establishment in California ranging from recently sown seed for rootstocks to seedlings ready for budding the commercial varieties.

At Glenn Dale, the major emphasis in research with fruit introductions is on virus studies. Apple, pear, and grape are being indexed for the presence of latent viruses for the first time as part of the quarantine procedure. The research studies include methods of detection and identification.

Detection of stone fruit viruses is more advanced. Sixty-five virus-free introductions have been released from the program. Of the foreign introductions indexed to date, 52% have been infected.

Evaluation of tropical and subtropical fruit introductions at the Miami station has been slowed by the devastating hurricanes of 1964 and 1965.

The testing of excised branches of avocado seedlings for cold hardiness in test chambers was continued. While inconclusive, the tests do indicate a difference in cold tolerance between progenies and between individual seedlings within progenies. Usually leaf blade hardiness (mesophyll) and vein hardiness (vascular tissue) appear to be correlated, but some plants have relatively hardy leaf blades with quite tender veins.

Horticulturists at the New York State Experiment Station reported that the 'Senga Sengana' strawberry, P.I. 264680, performed well during 1965. This leading variety from Europe produces medium-sized, dark, glossy berries which cap easily. The berries are about as soft as in 'Catskill'.

The 'Kerman' (P.I. 121776) pistachio, so far the overall best selection made at Chico, has shown a strong biennial bearing tendency as the trees grow older. There was a light crop in 1965, partially because of cool damp weather during the blossoming season. One tree of this clone at Chico has been a consistent cropper when others have failed. During 1965, it produced 160 lbs. of nuts, fresh weight, which gave about 46 lbs. of dry, clean, well-filled nuts. A local nut-handling concern paid \$1.00 per pound for the 1965 crop of pistachio nuts. Two local growers each marketed about 100 lbs.

b. Vegetables. The vegetable germ plasm collection was expanded considerably during the year. Hundreds of lines of Phaseolus vulgaris and other Phaseolus species from Central America and Mexico were added as a result of collecting activities in these areas. As rapidly as possible the new collections will be evaluated for disease and insect resistance. Of special interest at present are characters for resistance to bean root rot (Fusarium) and the bacterial blights. There is evidence that plant introductions may contain heritable characters for tolerance to the bacterial diseases. At the University of Nebraska, P.I. 165078 from Turkey was more tolerant to bean bacterial wilt than were commercial dry bean varieties. At the University of Wisconsin, P.I. 150414 from El Salvador showed a high degree of tolerance to races 1 and 2 of halo blight.

Phytopathologists located at the regional stations compiled disease resistance summaries during the year, listing sources of resistance in carrot, onion, pumpkin-squash, and southern pea (cowpea).



During the year 67 potato introductions were indexed for virus diseases. Of these, 20 introductions were released as virus negative and 47 positive. A revised inventory of introduced tuber-bearing Solanum species was issued by the IR-1 Project. All accessions are listed by Plant Introduction number.

Screening tests at the Georgia Experiment Station located sources of immunity to bean yellow mosaic virus in four introductions of Vigna sinensis (P.I.'s 154134, 160024, 175962, and 177101).

Cucumber breeders in South Carolina and Hawaii report several new breeding lines and varieties ready for release with resistance to downy mildew, powdery mildew, anthracnose, angular leaf spot, cucumber mosaic, and watermelon mosaic. Gynoecious lines for production of both slicer and pickle types are being developed in South Carolina. Several plant introductions supplied the genes for disease resistance and gynoecious flowering.

The 'Butter King' lettuce, selected from P.I. 211118 at Ottawa, was an All-American vegetable selection in 1965. It is a butterhead type larger than 'White Boston' and more tip burn resistant.

Out of 977 introductions of Pisum sativum screened by Oregon State Experiment Station, 31 remained uninfected with alfalfa mosaic virus, four were resistant to pea streak virus, four were resistant to powdery mildew, but none were resistant to clover mosaic virus.

The Utah Agricultural Experiment Station and the USDA have released to tomato breeders the curly top resistant tomato breeding line CVF4. This line is also highly resistant to verticillium and fusarium wilts. Three small-fruited species, Lycopersicon peruvianum var. dentatum (P.I. 128660), L. hirsutum (P.I. 126447), and L. pimpinellifolium were crossed to produce a resistant breeding line which was crossed with commercial tomatoes.

Vegetable varieties and breeding lines released during the year with germ plasm from plant introductions are: 'Tuckers Forcing' Tomato, a red fruited wilt and mold resistant forcing tomato; 'Mountaineer', a white half-runner bean introduced by New Hampshire Agr. Expt. Sta. from P.I. 236467; 'Poinsett', a slicer type cucumber with resistance to downy and powdery mildew and to race 1 anthracnose from P.I. 197087 and P.I. 220860; 'Tomato Breeding Line CVF4', a curly top resistant tomato breeding line released jointly by USDA and the Utah Agricultural Experiment Station with resistance from P.I. 128660 and P.I. 126447; 'Immokalee', a disease resistant determinate vine-type tomato with genes for resistance from P.I. 79532 and P.I. 126445.

c. Ornamentals. At Glenn Dale hybrids of the highly fragrant Camellia lutchuensis with odorless cultivars of C. japonica have produced their first flowers. Although odor in the hybrids varies considerably, some seem even more fragrant than the C. lutchuensis parent. The seedlings flowering to date have had single to semi-double flowers, usually not over two inches in diameter. They are being back-crossed to C. japonica. Pollination studies at Glenn Dale revealed that the 'Bradford' clone of Pyrus calleryana is self-incompatible. It is also incompatible with P. communis and P. Harbin (Hansen). It sets moderate crops of small fruit when pollinated with some other Oriental pear species and heavy crops with other clones of P. calleryana.

Ornamental clones developed from plant introductions are: 'Kinbyobu' chrysanthemum from P.I. 231097, released to nurserymen by the U.S. Department of Agriculture and the Montana Agricultural Experiment Station on January 11, 1965; 'Cheyenne', hardy privet from P.I. 107630, released to nurserymen by the U.S. Department of Agriculture on April 8, 1965; 'Longwood', clone of Euonymus fortunei from P.I. 275073, released to nurserymen by the U.S. Department of Agriculture on September 17, 1965.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### New Crop Evaluation

- Ackerman, W. L. and J. L. Creech. 1965. Progeny analysis of interspecific crosses between Ilex cornuta Lindl., and Ilex ciliospinosa Loes. Proc. Am. Soc. Hort. Sci. 86: 741-749.
- Ackerman, W. L. and H. F. Winters. 1966. Apple introductions from warmer climates. Fruit Varieties and Hort. Digest 20(1): 11-17.
- Brantley, B. B., C. W. Kuhn, and Grover Sowell, Jr. 1965. Effect of cucumber mosaic virus on Southern Pea (Vigna sinensis). Proc. Am. Soc. Hort. Sci. 87: 355-358.
- Corbett E. G. 1965. Ornamental kale. Am. Hort. Mag. 44(2): 67-79.
- Corbett, E. G. and E. M. Meader. 1965. The breeding behavior of the non-stoloniferous character in cultivated strawberries (Fragaria X ananassa Duchesne). Jour. of Heredity 56(5): 237-241.
- Corley, W. L. 1965. Some preliminary evaluations of okra plant introductions. Ga. Agr. Expt. Sta. Bull. N.S. 145, 16 pp.
- Crosier, W. F., W. L. Yount, and S. W. Braverman. 1965. Visual detection of seed treatments of wheat (ABS). Phytopathology 55: 1283.
- Dodge, A. F., W. L. Ackerman, and H. F. Winters. 1965. Performance of three privet introductions in the upper Midwest. Am. Hort. Mag. 44(2): 92-98.
- Higgins, J. J. and J. R. Haun. 1965. Leaves - Guide to crop management. 1965 Yearbook United Fresh Fruit and Vegetable Assoc. pp. 254-256, 260-261.
- Winters, H. F. and E. G. Corbett. 1965. A cold hardy ginger lily. Am. Hort. Mag. 44(3): 129-131.



## TROPICAL AND SUBARCTIC RESEARCH PROGRAMS

### Crops Research Division, ARS

Problem. Climatic extremes play an important part and present both problems and opportunities for agricultural research in the tropical and subarctic regions of the United States of America. Facilities provided in these locations, distant from the centers of research in the temperate zone, are utilized not only on indigenous problems but to complement, expand, and accelerate investigations in the temperate zone.

The problems are particularly aggravated by two conditions. These are the relative sparcity of agricultural knowledge, and the lack of a highly organized agriculture such as prevails throughout the temperate zone.

### USDA AND COOPERATIVE PROGRAM

Programs in this area include both basic and applied studies in a number of broad and diverse fields of agriculture. Program headquarters are located in Palmer, Alaska; Mayaguez, Puerto Rico; and the Island of St. Croix in the Virgin Islands. All are under, or are coordinated by the Crops Research Division.

In Alaska the research disciplines comprise soil and water utilization, crops research, plant diseases, entomology, marketing, management, economics, machinery, structures, material handling, and animal husbandry. Cooperation is effected with the Alaska Crop Reporting Service, the Alaska Division of Agriculture, Alaska's Cooperative Extension Service, and Soil Conservation Service, Matanuska Maid, Incorporated (the local farm cooperative) and other food wholesalers and retailers, U.S. Geological Survey, U.S. Weather Bureau, the North Central Region (of the experiment station's organization), various Canadian Experiment Stations, and the Matanuska Valley Breeders Association.

The Federal Experiment Station in Mayaguez, Puerto Rico, serves as the tropical research center for the Agricultural Research Service. The station conducts research with tropical plants of importance to the United States, and serves as a center for acquiring and evaluating new plant material of potential value in United States agriculture. The tropical location provides facilities for large-scale winter season testing of new breeding lines and varieties, and permits rapid seed increase of new genotypes developed at plant breeding stations in the United States. Through these procedures a tropical environment is used to reinforce and extend Departmental research programs in the United States. In some types of investigations such as sorghum breeding and selection, screening new cereal breeding lines or varieties for disease resistance, and field assay of new tobacco sucker control compounds, this tropical

research facility, in conjunction with Departmental activities in the States, permits completion of work in each calendar year which would otherwise require two years.

Investigations with sorghum, tobacco, sugarcane, soybeans, cereals, and Dioscorea are cooperative with Departmental research units located in the United States. Contributed funds from industrial sources support vanilla, cacao, and black pepper investigations. The Mayaguez station cooperates closely with the Agricultural Experiment Station of the University of Puerto Rico in conducting research for development of drug, insecticidal, spice, and other specialty crops of interest to agriculture in Puerto Rico. In addition to Crops Research Division activities, the Soil and Water Conservation Service also has offices at the Federal Experiment Station in Mayaguez.

The Virgin Islands Agricultural Research and Extension Program was initiated to give increased economic stability to the Agriculture and people of these Islands under unique sociological, environmental, and economic conditions. The program is based upon a tropical climate with low and irregular rainfall, undeveloped markets, difficult communications, undependable transportation, and ignorance of modern farming methods. Education through demonstrational research and extension activities is the best approach to raise the agricultural standards of the people concerned. Obviously the program is small and presently centers on the fields of soil science, animal husbandry, plant science, and home economics. Cooperation is effected with the Virgin Islands Corporation of the Department of the Interior and with the USDA's Forest Service and Soil Conservation Service. The two latter services have their local operations based at the Virgin Islands Agricultural Program headquarters.

The Federal scientific effort devoted to the programs of tropical and subarctic research totals 17.7 scientist man-years.

In Alaska, 2.8 scientist man-years were devoted to subarctic research on crops and 0.7 to plant diseases.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 60.6 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Alaska (Integrated total program)

Vegetables. Differences in vine and tuber producing capacity of potato plants were related to the part of the tuber used for seed. A seed-piece from the bud end of a tuber produced earlier maturing plants, and higher yielding plants, than seed from the stolon end. Storing seed tubers bud- or stolon-end up altered the vine and tuber producing efficiency of the plant.



A potato clone with fairly frost resistant foliage has produced good yields of high quality tubers, comparing favorably with Green Mountain and Kennebec. Evaluated by 11 cooperators at widely scattered sites returned favorable reports. Several clones producing high yields of good quality processing potatoes were planted for seed increase, producing lots of 900 pounds each, sufficient for commercial trials.

A new cabbage variety, bred and developed at College is nearly ready for release. Its superior characteristics are the ability to stand in the field for several weeks without cracking, good appearance, and good storability. A field seed increase block in Washington State attracted much attention because of its good quality persisting over many weeks.

Clear polyethylene mulch proved superior to "smoke" or black mulch. Marketable sweetcorn (Variety VH631) was produced under clear film mulch at Matanuska. Field yields of cucumbers (Mincu and Hybrid Spartan Dawn) and of summer squash (Hybrid "R") were also grown at Matanuska under clear mulch. Continued evaluation of green peas for processing and canning confirmed the superior qualities of Freezer 37, Freezer 69, Sprite, and Signet for a frozen pack.

Potato scab cultures were tested for pathenogenicity by inoculation of radishes growing in vermiculite. Only 3 of 150 cultures produced lesions. Attempts to develop antibiotic resistant cultures showed that resistant strains can be sorted out, resistance may not be stable, resistance to one antibiotic may be related to resistance to several others, and cross-over types were not found in mixed cultures growing on combinations of antibiotics. Potato skin spot is a wide spread affliction of Alaska-grown potatoes. Both Green Mountain and Alaska Russet are susceptible. No reduction of sprouting or tuber eye infection has been observed.

Yield trials of Kennebec potatoes with different initial percentages of x-virus failed to show differences in yield. The much greater increase in virus spread in 1965 over previous years may account for lack of difference in yield. Indications are that plant-to-plant spread is more easily effected than seedpiece-to-seedpiece spread. High-titre antiserum to virus-x was produced by injecting rabbits with 1, 2, and 3 cc antigen plus adjuvant intramuscularly at 3-day intervals. The antigen was prepared by expressing the juice from infected Nicotiana glutinosa, heating for 5 minutes at 55°C. centrifuging at low speed for 10 minutes and dialyzing the supernatant for 4 hours against tap water. Virus s was identified in our x-free Kennebecs by symptoms on Gomphrena globosa and Chenopodium album and by its thermal inactivation point.

Using the x-virus reaction on G. globosa, two lines of Green Mountain potatoes have been isolated that yield 20 per cent more than sister lines.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Alaska

- Dinkel, D. H. 1965. Chemical weed control in carrots grown in knik silt loam. 22nd Res. Rpt. NCWCC, p. 36.
- Dinkel, D. H. 1965. Chemical weed control in potatoes grown in knik silt loam. 22nd Res. Rpt. NCWCC, p. 37.
- Dinkel, D. H. 1965. Weed control under clear polyethylene mulch treatments. 22nd Res. Rpt. NCWCC, p. 37.

Puerto Rico

- Martin, F. W. 1965. Distyly and incompatibility in Turnera ulmifolia. Bul. Torrey Bot. Club 92(3): 185-192.
- Martin, F. W. 1965. Incompatibility in the sweet potato, a review. Ec. Bot. 19(4): 406-415.
- Newton, R. C. and D. K. Barnes. 1965. Factors affecting resistance of selected alfalfa clones to the potato leafhopper. Jour. Ec. Ent. 58(3): 435-439.

Virgin Islands

- Krochmal, A., R. M. Bond, and A. L. Frederiksen. 1965. Pineapple production studies in the U. S. Virgin Islands. Ceiba 11(2): 82-89. Sept.
- Krochmal, A. and M. R. Henderson. 1966. Packing and air shipment of 'Solo' Papaya from Virgin Islands to Puerto Rico. Univ. of Puerto Rico Expt. Sta. Misc. Bull. 50, Jan. (17 pp. in English and Spanish).



## WEED CONTROL

Crops Research Division, ARS

Problem. There are more than 30,000 species of weeds distributed throughout the world and about 1,800 of these cause serious economic losses each year. About 600 weed species compete with crops for water, mineral nutrients, light, space, and other growth requirements in the United States.

The weeds reduce crop yields, efficiency of land use, crop and livestock quality, effectiveness of water management, and cause losses in human efficiency. They harbor insects and disease-producing organisms which damage crops.

Many species of weeds are poisonous to humans, domestic animals, and wildlife. Weeds produce toxins and allergy-causing pollens which result in an annual loss of 333 thousand work days, 3.7 million days of restricted activity, and one-half million days spent in bed. Poisonous weed seeds and plant parts may be harvested and processed in foods as contaminants where they may become a threat to public health.

Weeds increase labor and cultivation costs, and reduce harvesting and processing efficiency. Weeds are among the most serious obstacles limiting the mechanized production of food, feed, and fiber crops. In the 10-year period 1951-61, the annual losses due to weeds ranged from 3 to 18 percent of the value of the crops produced.

The national annual loss in crop yields and quality due to weeds has been estimated to be about \$2.5 billion and the cost of controlling weeds, an additional \$2.6 billion each year.

Excellent progress has been made in developing cultural, mechanical, biological, chemical, and integrated methods of weed control. However, many weed problems remain unsolved and most of the methods that have been developed need improvement. The inadequacy of information on the nature, growth, development, reproduction, spread, and survival characteristics of weeds is a serious deterrent to the development of improved methods of control.

The problems associated with the effective and safe use of herbicides are increasing--especially practices which involve the addition of herbicides to water for the control of aquatic weeds. There are serious voids in fundamental information on the relation between molecular structure of herbicides and their absorption, movement, mechanisms of action, metabolism, behavior, persistence, and fate in plants, soils, and water.

The problem of herbicide residues that result from treating one crop or the soil in a previous season causing damage or occurring in a second crop in the rotation, whether treated or not, is becoming increasingly serious. Current information is not adequate to develop herbicide-crop rotations that prevent the accumulation of herbicide residues in soils and prevent the occurrence of residues in food and water. Information on the interacting effects of herbicides, insecticides, and other pesticides on plant growth is not adequate to avoid or minimize the problems associated with the combinations of pesticides used in crop production and protection.

#### USDA AND COOPERATIVE PROGRAM

The U. S. Department of Agriculture has a continuing long-term program of basic and applied studies directed toward the solution of weed problems on farms. Research on reducing damage to crops by weeds includes studies of the life histories and growth patterns of individual weeds and the use of cultural methods, biological agents, and herbicides for their control. Weed research includes physiological and biochemical studies to determine the mechanisms involved in absorption and translocation, the mode and site of action, the effect of environment on plant responses to herbicides and the metabolism and fate of herbicides in plants and soils. Comprehensive studies are made to develop principles, practices, and methods of using herbicides and other weed control techniques in solving regional agricultural weed problems in horticultural crops.

Weed research is being conducted by the Department at 37 different locations in 26 States and Puerto Rico. All of this research is conducted cooperatively with State Agricultural Experiment Stations with the exception of the research at Beltsville, Maryland; Denver, Colorado; and Mayaguez, Puerto Rico. There is also cooperation with other Federal agencies which ranges from informal exchange of information to formal arrangements providing funds and personnel in support of weed control research. Industrial companies cooperate in furnishing experimental chemicals, equipment, and funds essential to rapid progress in weed control investigations.

The total Federal scientific effort devoted to weed control research is 82.0 scientist man-years. Of the total, 17.2 man-years are devoted to physiological and ecological basic research which is broadly applicable to all crop commodities; 3.5 to horticultural crops; 3.2 for weed control in vegetable crops; and 0.3 for weed control in deciduous fruits and tree nuts.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 110.6 scientist man-years is devoted to this area of research.



PROGRESS - USDA AND COOPERATIVE PROGRAMS

1. Vegetable Crops

a. General

Herbicide Evaluation. Preliminary herbicide evaluation studies were conducted at Tifton, Georgia, on several vegetable crops to determine their effectiveness in the southeastern area. Crops included in these experiments were cantaloupe, cucumber, watermelon, squash, lima bean, snapbean, southern pea, tomato, mustard, turnip, cabbage, collards, okra, and sweet corn. Amiben controlled weeds selectively on certain cucurbits and legumes, diphenamid selectively controlled weeds in legumes and tomatoes, and DCPA controlled weeds in legumes and crucifers. Most of the test species were tolerant to CDEC, linuron, diuron, and CIPC though having excellent herbicidal properties showed a limited selectivity on the various crops.

NPA and prometryne were selective on legumes, prometryne and DMPA on okra, and NPA on legumes, okra, and the cucurbits. Outstanding among the herbicides evaluated was bensulide which caused little or no injury to any of the crops studied and yet showed an adequate level of weed control.

Effects of Herbicides on Composition. Research on the effect of herbicide treatments on quality and mineral and vitamin content of potatoes and tomatoes is in progress under a research contract at Ohio State University. Initial data have not shown a significant shift in composition due to effective herbicide treatments in plantings of these crops.

b. Asparagus. Studies on the long-term effects of repeated applications of monuron, DCPA, amiben, diphenamid, linuron, simazine, and dichlobenil on the yield and quality of asparagus were continued at New Brunswick, New Jersey. Spring applications of diphenamid, dichlobenil, and amiben lost much of their effectiveness prior to the end of the cutting season. Monuron, linuron, simazine, and DCPA all controlled the weeds throughout the cutting season. Dichlobenil was the only compound that significantly reduced the yield below that of the clean-weeded plots. Quality of asparagus was not affected.

c. Cantaloupes. At Weslaco, Texas, herbicides performed more efficiently in cantaloupe plantings when herbicides were incorporated into the upper layer of soil. DCPA, bensulide, and NPA controlled weeds best when incorporated 2 inches deep. Bensulide was outstanding in these experiments. CDEC controlled weeds selectively when incorporated to a depth of 3/4 inch, but a delay of ten days in planting after treatment was required to insure selectivity when it was incorporated to a depth of 2 inches. CDEC persisted longer when incorporated.

- d. Carrots. At Weslaco, Texas, trifluralin and bensulide were outstanding herbicides for weed control in carrots regardless of soil incorporation or time of planting when rainfall occurred. Linuron and prometryne were less selective. This was especially true in soil surface applications.
- e. Cucurbits. Two varieties each of cucumber, cantaloupe, watermelon, and squash, and one variety of pumpkin were evaluated for their tolerance to DCPA, NPA, amiben, DMPA, bensulide, UC-22463A, and UC-22463 on a Tifton loamy sand at Tifton, Georgia. The varieties reacted in a similar way to each of the compounds. Herbicides that gave effective weed control with adequate crop tolerance were NPA and bensulide on cucumbers; NPA, bensulide, and amiben on cantaloupe; NPA, UC-22463, bensulide, and DMPA on watermelon; and UC-22463, bensulide, DMPA, and amiben on squash and pumpkin.
- f. Lettuce and Onion Soils Affected by Cotton Herbicide Residues. Injury has been observed on lettuce and onions grown in rotation with cotton treated with diuron in Texas. In research at Weslaco, Texas, 1-1/2 pounds of diuron incorporated for control of weeds in cotton reduced onion and lettuce yields when the crops were planted 8 months after the cotton pre-emergence treatment. Yield reduction appeared to be associated with lack of vigor rather than loss of stand. Diuron layby treatments on cotton caused severe injury to lettuce plantings in rotation. Slight inhibition of growth occurred in onion plantings in rotation. The long persistence of diuron used as preemergence treatments in cotton show that it is not advisable to use diuron on cotton where diuron-sensitive vegetables are to be grown in the rotation. The results indicate that diuron is more slowly deactivated when soil incorporated. This may be due to reduced photo inactivation.
- g. Lima Beans. In experiments at Tifton, Georgia, benefin and UC 22463 applied as preemergence treatments gave effective weed control and did not cause injury to the crop. Selectivity of CIPC, DCPA, and amiben on lima beans was moderate in these studies.
- h. Onions. Incorporated and soil surface applications of DCPA and bensulide controlled purslane (Portulaca oleracea L.) in onions at Weslaco, Texas, regardless of incorporation depth or time of planting when rain occurred. CP-31393 had no effect on weed or onion growth regardless of application method.
- i. Sweet Corn. Experiments were conducted at Beltsville, Maryland, to study the efficiency of atrazine, cultivation, and handweeding used separately and in various combinations to control weeds in sweet corn. Compared to unweeded control plots, yields were increased: 400 percent by cultivation; 500 percent by handweeding; 600 percent by cultivation and handweeding; and 450 percent by use of atrazine for weed control. Cultivation combined with handweeding did not reduce yields due to root pruning.



j. Sweet Potatoes. Amiben, trifluralin, vernolate, DCPA, and diphenamid were used as postplanting weed control treatments in sweet potatoes at New Brunswick, New Jersey. None of the herbicides caused visible injury and excellent vine growth occurred in all treatments. Yields were reduced in the vernolate treatments. Significant changes in flavor did not occur.

k. Tomatoes. Under relatively low soil temperatures, little rainfall, and high evaporation rates at Weslaco, Texas, pebulate and bensulide controlled amaranth and barnyardgrass at 5 lb/A; whereas, diphenamid controlled only barnyardgrass at 10 lb/A. None of the herbicides decreased the yield of tomatoes although they were incorporated to the depth of tomato seed immediately before planting.

In controlled environment studies to determine the relative susceptibility of weeds in tomatoes and peppers to diphenamid at Weslaco, Texas, it was found that the growth of ryegrass, oats, and barnyardgrass was reduced by concentrations of one part per million or less of diphenamid; whereas, 12 parts per million or more of diphenamid were required to reduce the growth of pigweed, tomato, and pepper.

## 2. Fruit Crops

a. Apples. Continuation of long-term experiments on weed control in apple orchards at New Brunswick, New Jersey, have included the experimental use of diuron, simazine, CIPC, diuron plus CIPC, and amitrole in spring and fall applications and the use of plastic mulches. None of the treatments have caused visible injury to the trees. Yields were not reduced and quality factors did not differ significantly.

b. Blueberries. Long-term studies of weed control problems in blueberries begun in 1960 were continued at New Brunswick, New Jersey. The results show that effective weed control rates of simazine and diuron for a period of 6 years did not injure the plants or fruit or cause significant differences in flavor.

c. Cranberries. Long-term studies on weed control in cranberries were continued at New Brunswick, New Jersey. Dichlobenil did not reduce bloom or set as a result of fall applications at rates of 2 to 8 lb/A. However, fruit size was reduced at all rates, suggesting that this herbicide should not be used except for the control of severe weed populations.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Danielson, L. L. 1965. Recent advances in horticultural crop weed control in the United States of America. 1965 Australian Weed Cont. Conf. Handbook of Working Papers. 1(4):19-22.

- Menges, R. M. and J. L. Hubbard. 1966. Soil-surface and soil incorporation applications of herbicides in furrow-irrigated spinach. American Soc. Hort. Sci. Proc. 87:363-370.
- Menges, R. M. and J. L. Hubbard. 1965. Preplanting, soil-incorporated application and preemergence application of herbicides in furrow-irrigated onions. Western Weed Cont. Conf. Proc. 20:32.
- Taylorson, R. B. and R. W. Toler. 1966. Weed control in southern pea and lima beans. Southern Weed Conf. Proc. 19:181-193.
- Taylorson, R. B. 1966. Tolerance of several cucurbits to preemergence herbicides. Southern Weed Conf. Proc. 19:195-199.
- Taylorson, R. B. 1965. Delayed preemergence weed control in seeded tomatoes and peppers. Weeds 13:306-308.
- Taylorson, R. B. 1965. New herbicide for sweet potatoes. American Soc. Hort. Sci. Proc. 86:517-522.
- Welker, W. V., Jr. 1966. Weed control in asparagus. Northeastern Weed Cont. Conf. Proc. 20:35.



## NEMATODE IDENTIFICATION, PHYSIOLOGY, AND CONTROL

Crops Research Division, ARS

**Problem.** Plant-parasitic nematodes attack all crop plants, but cause varying damage and crop losses, depending on the nematode involved, type of crop, crop tolerance, and environmental conditions. Most plant-parasitic nematodes infect roots and other underground parts of plants, but some very important species attack bulbs, stems, leaves, and flowers. Damage initiated by nematodes is often extended by bacteria, fungi, and viruses. Damage can be greatly reduced by use of varieties resistant to nematodes, but only a relatively few resistant varieties have been developed. Development of resistant varieties is a time-consuming task and does not completely protect the crop because multiple nematode resistance is difficult to attain and is lacking in all varieties thus far developed. Crop rotations have been devised to reduce some of our more important nematode problems, but rotations rarely fit modern management practices, or are uneconomical. While naturally-occurring biological agents undoubtedly have a great influence on nematode populations, manipulation and use of these principles for economic control is not yet practical. Great advances have been made in chemical control, but use of nematocides on many crops is not economically feasible. More effective and cheaper nematocides, and improved methods of application are needed.

### USDA AND COOPERATIVE PROGRAM

The Department has a long-term, continuing program of basic and applied research on various phases of nematology. In the past few years, as State nematology programs have developed, there has been increased emphasis on basic research in the Department's program. Fundamental research on nematode taxonomy, pathology, ecology, and physiology is located at Beltsville, Maryland. In addition, 13 field stations combine applied and basic research approaches to solve nematode problems on various crops. Research on nematodes affecting citrus is located at Phoenix, Arizona; Orlando, Florida, and Weslaco, Texas; on deciduous fruits and tree nuts at Tifton and Byron, Georgia; and Logan, Utah; on vegetable crops at Tifton, Georgia; Charleston, South Carolina; Salinas, California; and Baton Rouge, Louisiana; and on ornamentals at Tifton, Georgia, and Orlando, Florida. The work at all field stations, except in Florida and South Carolina, is in cooperation with the respective State Agricultural Experiment Stations.

Contract Research is in progress at several universities.

PL-480 projects are as follows: at Poznan, Poland, on the nature of resistance to nematodes; at Skierniewice, Poland, on nematodes attacking strawberries; at La Molina, Peru, for research on the Golden Nematode of potatoes; at Aligarh, India, for nematodes attacking vegetables; and at Rehovot, Israel, on nematodes as vectors of diseases on citrus and other fruit crops.

The Federal scientific effort devoted to nematology research in FY 1965 totaled 29.3 man-years including 4.8 man-years per year of contract and grant research. Of this 14.2 were devoted to basic research on nematodes; 1.4 to research on citrus; 1.7 to vegetables; 1.6 to flowers and ornamentals; and 1.5 to deciduous fruit and tree nuts.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 53.6 scientist man-years is devoted to nematology research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### 1. Nematodes in Fruit Crops.

a. Citrus. Application of dibromochloropropane (Nemagon) in irrigation water at 5 gallons per acre, has controlled the citrus nematode for 4 years on Valencia oranges in Arizona; 1965 yields of Sunkist oranges (72's or larger) were 132 percent higher from treated than untreated groves. An 8-year study of dibromochloropropane irrigation treatment of Marsh grapefruit indicate that the citrus nematode is controlled by repeated applications of 2 gallons per acre of chemical every two years; in 1965, grapefruit (48's and above) yield was increased 44 percent over untreated groves. Nematode research on citrus in Florida has been expanded to develop methods of controlling all nematodes attacking citrus, including burrowing, citrus, sting, stubby-root, and dagger nematodes. In 1965, one of the largest Florida nurseries that was previously "certified free" of the burrowing nematode, was found badly infested. Infected nursery stock is considered a principal means of spreading nematodes into citrus groves. An intensified research program has been started to free citrus nursery stock of all nematodes.

b. Cherries. The pathogenicity of root-knot (Meloidogyne hapla), root-lesion nematodes (Pratylenchus minyus), and dagger nematodes (Xiphinema americanum) on cherries (Prunus mahaleb) were studied in greenhouse tests at Logan, Utah. Larvae of the root-knot nematodes penetrated cherry roots and caused spindle-shaped root-knot galls, but there was no apparent reproduction. Under favorable soil moisture and temperature conditions, the dagger nematode readily reproduced on cherries. However, the greatest damage and population increase occurred for root-lesion nematodes. These nematodes invaded the lateral roots and produced extensive necrosis, which was followed by extensive secondary invasion of soil fungi. The demonstrated pathogenicity of root-lesion nematodes, and their frequent occurrence, indicate that these nematodes are responsible for a serious production problem in the intermountain area.



## 2. Nematodes in Vegetables.

At Charleston, South Carolina, good resistance to the southern root-knot nematode was found in Cucumis ficifolius, C. anguria, C. metuliferus, C. heptadactylus, and C. longipes. These species are being used in interspecific crosses in an attempt to bridge the genetic gap with C. melo. Cooperative studies to develop root-knot resistance in bush beans are progressing rapidly. Breeding lines now possess several times more resistance to root-knot nematodes than Alabama No. 1 or No. 2, and Black Valentine. One of the more promising bush bean nematode resistant lines, B-3864-IN-2-M3, does not exhibit nematode galling, which is the usual indicator of resistance. However, histopathological studies revealed that larvae enter the roots and cause necrosis, indicating that the resistance is expressed as a hypersensitive reaction of tissues that restricts feeding and prevents development of the nematode. Cooperative studies were initiated in 1965 to develop a root-knot resistant 'Jackson Wonder' type lima bean, for which no resistance is presently available. Crosses of 'Nemagreen' and 'Jackson Wonder' show promise for root-knot resistance. Evaluation of chemicals for use in tomato transplant production in Georgia showed, for the second year, that combinations of pesticides gives high production and improved quality of transplants. Combinations of nematocides (Union Carbide 21149 and cynem) with a herbicide (PEBC) and a fungicide (Niagara 5961) averaged between 15 and 20 high grade plants per foot compared to less than 1 plant per foot in untreated control plots where nematodes, pathogenic fungi, and weeds reduced stands and quality. The combination pesticide treatments were as effective as wide-range soil sterilants such as DD-MENCS or 1,3D-PBC. Cost of wide-range soil fumigants is at least four times higher than the total cost of combined pesticide mixtures. In Louisiana, the new nematocide tetrachlorothiophene (Penphene) controlled root-knot and increased 'Goldrush', 'Centenial', and L-9-30 (advanced breeding line) sweet potato yields (US No. 1's) by 115, 54, and 32 bushels per acre, respectively. 'Goldrush' and 'Centenial' are nematode susceptible, whereas L-9-39 is resistant to root-knot nematodes. Field evaluations established that the root-knot susceptible 'Goldrush' is resistant to the destructive reniform nematode, and all root-knot resistant sweet potato varieties were susceptible to the reniform nematode, indicating that factors controlling resistance to root-knot and reniform nematodes may differ in sweet potatoes.

Chemical control experiments in Uttar Pradesh, India, under a PL-480 project, established that over fifteen species of plant-parasitic nematodes limit vegetable production. In a number of field trials, yield increases of 10% to over 150% were obtained for potatoes, tomatoes, beans, cowpeas, okra, gourds, and Luffa following D-D treatment. Control of the 'Golden nematode' in Peru, under a PL-480 project, was obtained with dichloropropenes (D-D), sodium methyl dithiocarbamate (SMDC), dimethyltetrahydro-thiadiazinethione (DMTT), and dibromochloropropanes (DBCP).

3. Nematodes in Ornamentals. The southern and peach root-knot nematodes were controlled, possible 100 percent, on container-grown Ilex crenata var. Helleri by three water drenches of Bayer 25141 at 30 day intervals. Single applications gave good control, but not approaching eradication.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Fruit

Golden, A. M., and R. Converse. 1965. Nematodes and raspberries in the eastern United States. Plant Disease Reporter 49: 987-991.  
Feldmesser, J., and C. I. Hannon. 1965. An evaluation of the role of Pratylenchus in decline of citrus. Phytopath. 55: 1058.

##### Ornamentals

Gill, D. L., and J. M. Good. 1965. Use of fumigants in Easter Lily production. The Florists' Review. 136(3524): 16-17, 58-59.  
Nickle, W. R., and A. M. Golden. 1965. Ditylenchus dipsaci injury to Penstemon digitalis. Plant Disease Reporter. 49: 991-993.

##### Vegetables

Birchfield, W., and W. J. Martin. 1965. Effects of reniform nematode populations on sweet potato yields. Phytopath. 55: 497.

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS

Barker, K. R., Worf, G. L., and Epstein, A. H. 1965. Nematodes Associated with the Decline of Azaleas. Plant Disease Reporter. 49: 47-49. (Wis.)  
Helton, A. W. 1965. Chemotherapeutic Action of Dimethoate Against a Root-Knot Nematode in Greenhouse Tomato Plants. Plant Disease Reporter. 49: 352-356. (Idaho).  
Sendstodt, R., and Schuster, M. L. 1965. Host-Parasite Interaction in Root-Knot Nematode-Infected Carrot Tissue. Phytopathology. 55(4): 393-395. (Neb.)



EPIDEMIOLOGY AND MYCOLOGY OF PLANT DISEASES,  
AND MUSHROOM CULTURE

Crops Research Division, ARS

Problem. Identification of the causative agents of disease, as well as a knowledge of their life cycles, epidemiology, ecology, and relationship to other organisms, are fundamental for the application of disease prevention and control methods. To provide authoritative identification of plant pathogens, there is urgent need for broader taxonomic coverage of the fungi. Basic research is needed on their characteristics and classification. We require additional information on the factors involved in epidemic outbreaks, so that we may develop effective disease forecast methods that will facilitate prevention and control programs.

In order to permit controlled breeding and improvement of the common mushroom and to place the industry on a sound footing, extensive basic studies of the microbiology of composting materials, nutrition and environmental physiology of edible fungi and their diseases, and cytogenetics should be conducted.

USDA AND COOPERATIVE PROGRAM

The Department research is conducted at four locations. Identifications of plant pathogens and other fungi are made and the National Fungus Collections are maintained at Beltsville, Md. Taxonomic studies are made on parasitic leaf-and-stem fungi, wood-rots, and certain lower fungi important to grain storage.

Research is conducted on the epidemiology of tomato and potato late blight, bacterial spot of pepper and tomato, lima bean, downy mildew, brown spot of tobacco, southern blight of corn, and yellow dwarf of barley to develop accurate plant disease forecasting methods. Epidemiological research continues in cooperation with the State Agricultural Experiment Station at Raleigh, N. C.; Ames, Iowa; and University Park, Pa. The monthly "Plant Disease Reporter" emphasizes new records of disease occurrence, serious outbreaks and new controls.

Applied and basic mushroom studies are conducted at Beltsville on "artificial" or substitute composts and nutritional and environmental effects on mushroom growth, yield, and quality. Studies are also underway to devise effective breeding and genetic studies to improve mushroom strains in yield and quality.

Department scientific effort devoted to research in this area includes 5.0 scientist man-years on epidemiology and 2.0 on mushrooms.

PROGRAM OF STATE EXPERIMENT STATIONS

Current research at State Agricultural Experiment Stations amounts to 26.8 scientist man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Epidemiology

1. Late blight of potato and tomato. Six dew duration recorders, including dew balance types made in England and Germany and lamb gut and glass plate types made in the United States, were tested for the World Meteorological Organization in a potato and cereal plot at Ames, Iowa. Similar tests were conducted at Poona, India, by the Indian Meteorological Service. At Ames, the dew balance recorders seemed less reliable than the lamb gut and glass plate recorders. Recorders differed in number of hours of dew recorded. The precise time of dew deposition was difficult to interpret on the dew balance recorders.

2. Bacterial spot of pepper and tomato. A second season of controlled experiments again demonstrated infection by Xanthomonas vesicatoria surviving over winter in diseased plant parts.

Pseudomonas syringae, previously found to be the cause of a leaf spot closely resembling that caused by X. vesicatoria, was isolated from one pepper plant bed in Sampson County, North Carolina. Only a trace of infection was noted during the season in fields supplied with plants from this bed. This observation substantiates previously reported indications that although P. syringae may occur occasionally in pepper plant beds it apparently is not likely to become serious under local conditions.

B. Mushrooms

1. Ventilation requirements during mushroom cropping. Mushrooms grew best when growing rooms were supplied with: a) At least 10-20 ft<sup>3</sup> of fresh air per ft<sup>2</sup> of bed surface per hr; b) as much air movement over the beds as feasible without excessively drying either soil or mushrooms; and c) a relative humidity between 75 and 90%. Fresh air is required in the growing room to lower the level of CO<sub>2</sub> and of any other gases which might be toxic to mushrooms. The level of CO<sub>2</sub> increased or decreased inversely with the rate of fresh air introduced into the room and directly with the rate of CO<sub>2</sub> released into the air from mushroom trays. The conditions which increase CO<sub>2</sub> production and, therefore, the fresh air requirements are: Increased bed surface; greater bed depth; more vigorous spawn varieties; early part vs. late part of the cropping period; and increased temperature. The minimum of fresh air required for optimum yields was somewhat higher than for the prevention of excessively long stems and small caps. With a constant supply of fresh air, the ratio of air space to bed space within a growing room affected mushroom production only secondarily, through its effects on the amount of bed or tray area within the room and on the rate of air movement over the beds or trays. The minimum level of CO<sub>2</sub> within the compost which affects mushroom production is quite high and poses no problem for growers. Closing up the mushroom house for several hours a day during hot weather does not drastically reduce yields.



2. The effects of injections of different nutrient solutions on mushroom, *Agaricus bisporus* in compost were studied at Beltsville, Maryland. Solutions were injected into the compost by using a hypodermic syringe at different times, before and after casing the compost. Addition of vitamins,  $(\text{NH}_4)_2\text{SO}_4$  and glucose did not affect mushroom yields. Casein hydrolysate, however, increased yield under some conditions. Based on amino acid content, this yield increase was comparable with that reported by others for mixing cottonseed meal into spawned compost. Prior nutritional status of the compost may have affected the results of supplementation.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Person, L. H. 1965. Development of bacterial leaf spot of pepper in the field from overwintered inoculum of *Xanthomonas vesicatoria*. (Abstr.)  
Phytopath. 55: 1071.

## VEGETABLE INSECTS

### Entomology Research Division, ARS

Problem. More effective, economical, and less objectionable methods of controlling insect and mite pests of vegetables in the field without leaving undesirable residues on or in the marketed product or in the soil, and without affecting the flavor or quality of the product, or adversely affecting beneficial insects, are the major objectives of this research. Insects and mites are important limiting factors in the production of high-quality vegetables. These pests reduce yield, lower quality, spread plant diseases, contaminate the marketable product, and increase the cost of production. Use of insecticides and miticides is currently the most effective direct method of control; however, application too close to harvest may result in residue problems. There is concern over the possibility of contaminating animal products by feeding crop refuse or byproducts of peas, beans, sweet corn, or other vegetables treated with insecticides to livestock. Drift of certain insecticides into non-target areas may also cause problems. A number of vegetable insects have developed resistance to certain insecticides. Research is needed on methods for better utilization of predators, parasites, and diseases of vegetable insects and mites; bioenvironmental and cultural methods; development and utilization of more effective traps and lures; new approaches to control including radiation, chemosterilants, and antimetabolites; evaluation of insecticide application equipment; and the practical integration of non-chemical and chemical methods in area control of vegetable insect and mite pest populations. Additional emphasis should be placed on research to develop vegetable crops resistant to insects and to determine the factors responsible for resistance when found. Research is needed on insect vectors of vegetable diseases and the role they play in the dissemination of viruses. The heavy losses caused by viruses transmitted by insects to a variety of vegetable crops emphasizes the importance of research in this field.

### USDA AND COOPERATIVE PROGRAM

The Department has a long-term program of applied and basic research on vegetable insects with stations at Mesa, Ariz., Riverside, Calif., Tifton, Ga., Twin Falls, Idaho, Lafayette, Ind., Beltsville, Md., Wooster, Ohio, Forest Grove, Oreg., Charleston, S.C., and Yakima, Wash., in cooperation with the respective State experiment stations and industry. Much of the work is in cooperation with the Crops Research, Pesticides Regulation, and Agricultural Engineering Research Divisions. Work in Idaho is also cooperative with the Idaho Bean Commission and that in Maryland with the Northern Utilization Research and Development Division and the Human Nutrition Research Division. Work in Oregon is conducted jointly with the Agricultural Engineering Research Division. Research is being conducted in Louisiana under contract to the Louisiana Agricultural Experiment Station and in Indiana under a research grant to the Indiana Agricultural Experiment Station.



Work in Karaj, Iran, on insects affecting vegetable legumes is supported with funds supplied by the Agency for International Development (AID) under the grain legume production project in cooperation with the Crops Research Division, the Soil and Water Conservation Research Division, Karaj Agricultural College, the Iran Ministry of Agriculture and the Iran Plan Organization. The Department also furnishes periodic consultant service on bean and other vegetable insects to the Ministry of Agriculture in El Salvador.

The Federal scientific effort devoted to research in this area totals 24.1 scientist man-years. Of this number 2.1 is devoted to basic biology, physiology, and nutrition; 3.5 to insecticidal and cultural control; 4.1 to insecticide residue determination; 4.5 to biological control; 2.9 to insect sterility, attractants, and other new approaches to control; 1.7 to evaluation of equipment for insect detection and control; 3.7 to varietal evaluation for insect resistance; 0.3 to insect vectors of diseases; and 1.3 to program leadership.

In addition Federal support of research in this area under contracts and grants provides 1.2 man-years. Of this total, 0.2 is devoted to biological control; 0.6 to insect sterility, attractants, and other new approaches to control; and 0.4 to varietal evaluation for insect resistance.

Three projects have recently been initiated under PL 480 research grants. These include research in India on Indian Jassidae with particular reference to Circulifer and related genera and their importance as vectors of plant virus diseases (Project A7-ENT-22) and on physiological factors governing susceptibility or resistance of crop plants to leafhoppers (Project A7-ENT-44) and in Israel on factors influencing variations in resistance of insects to insecticides (Project A10-ENT-13).

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 49.0 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Basic Biology, Physiology, and Nutrition

1. Cabbage looper. When dye-marked male cabbage looper moths were released in the center of an 0.8 square mile area throughout which 15 blacklight traps were distributed at Riverside, Calif., recoveries decreased with increasing distance from the release point. Over 90% of the captured released moths were in traps within 1 mile of the release point. However, a few moths were caught 10,000 feet away.

When 1-day-old male moths were released, none were recaptured the night of the release. When 4- to 5-day-old male moths were released, 12.2% were recaptured on the night of the release. Fifty percent of the total recaptured were taken within 1.5 days after release and 90% within 4.3 days. Low

numbers of released male moths were caught up to 7 days after release. Total male cabbage looper populations estimated in July, October, and November ranged from 504 to 54 male moths per acre. Peak catches of wild cabbage looper moths per night per trap occurred in July in 1965 in contrast to August in 1964. Moth catch per night per trap decreased sharply a month earlier in the fall and increased about a month earlier in the spring in 1965.

Blacklight traps operated in each case for 2-hour intervals starting at 6 p.m. and ending at 6 a.m. showed that 58% of the male moths were caught in traps operated between midnight and 4 a.m., 15% and 16% from 10 p.m. and 12 p.m. and 4 a.m. to 6 a.m., respectively, and only 5% and 6% from 6 p.m. to 8 p.m. and 8 p.m. to 10 p.m., respectively.

At Mesa, Ariz., weekly releases of marked laboratory-reared cabbage looper moths were made starting in June 1965 in a 100-square-mile study area within which 25 15-watt blacklight traps were spaced at 2-mile intervals. Releases were made at 2-mile intervals with 16 release points 1.4 miles from each trap; at 1-mile intervals with 81 release points 75 feet and 1 mile, respectively, from each trap; and at a central release point. Releases consisted of 100 marked moths at each point except the central release. Here the releases varied with the numbers of moths available but usually amounted to several thousand at a given time. From release and recovery data different methods of population estimates are being investigated based on the ratio of released marked moths recovered to native moths trapped. Flight distances and time required to fly certain distances have also been investigated, as well as direction of flight. Of 27,357 moths released in the center of the area between June and November 1965, 0.16% were recovered, 70% of which flew in an easterly direction.

Flight of cabbage looper moths of various ages were tested in a flight meter in the laboratory at Riverside, Calif., when fed 10% sucrose, distilled water, or starved. Irrespective of the moth age, flight of male moths when fed distilled water or starved was 30% and 51% less, respectively, than the flight of moths fed 10% sucrose. Under the same conditions female-moth flight was 40% and 57% less, respectively, than the flight of females fed 10% sucrose. The maximum distances traveled by distilled water fed and starved male moths in 24 hours were 32.82 and 17.72 miles, respectively. The maximum distances for comparable female moths were 28.46 and 28.61 miles. Flight of 3-day-old male cabbage looper moths fed 1% tepa in 10% sucrose solution or sprayed with 1% tepa and fed 10% sucrose was decreased 76% and 48%, respectively, when compared to moths fed 10% sucrose without tepa.

Wheat bran and cottonseed meal were promising as the plant products in the cabbage looper larval diets in tests made at Riverside, Calif.

Also at Riverside, Calif., laboratory studies showed that no cabbage looper mating occurred below temperatures of 60° F. Reduced mating occurred at 60 and 90° F during the first 24 hours of confinement. Mating occurred most



frequently at temperatures of 70 and 80° F. Little or no oviposition occurred at temperatures below 60° F. The total numbers of eggs laid by moths held at 60, 70, 80, or 90° F were not significantly different; however, at 60° F fewer eggs were laid per 2-day oviposition period and the number of days moths oviposited was extended. Longevities of males and females at 40, 60, 70, or 90° F were not significantly different although there appeared to be a tendency toward decreased longevity with increasing holding temperatures. Moths of both sexes held at 50° F lived an average of more than 30 days.

2. Noctuid Moths. At Mesa, Ariz., cabbage looper, alfalfa looper, beet armyworm, yellow-striped armyworm, corn earworm, and granulate cutworm moths collected in blacklight traps show that the seasonal peak of populations for all six of these species comes in August and September. Lettuce, cauliflower, brocolli, and cabbage are planted in late August or early September in southern Arizona. These noctuid insects are major pests of one or more of these crops. With the exception of the corn earworm, moths of all other noctuid species studied are present in low numbers during the winter and early spring months. Cabbage looper and corn earworm moth populations reach their first peak in April or May and then drop to a comparatively low level during June and early July before attaining high seasonal peaks in August and September.

3. White Cotton Root Aphid. At Yakima, Wash., thief and pavement ants were found attending white cotton root aphids. This aphid attacks the roots of various vegetable crops and is quite helpless, depending on ants for its care.

4. Cowpea Curculio. A technique was developed at Charleston, S.C., for rapid sex determination of cowpea curculio by visual examination of pupae.

5. Southern Potato Wireworm. Southern potato wireworm adults constituted 99.4% of the elaterids caught in a single 15-watt blacklight trap operated throughout 1965 in a vegetable-growing area at Charleston, S.C., and 97% of the elaterids taken in 8 similar traps during August and September 1965 in a tobacco-growing area. Trap studies indicated that southern potato wireworm adults will fly over a small farm pond and to a height of at least 100 feet over a wooded area. Larvae from cultivated soil samples taken in 18 fields on 10 farms during October and November 1965 were 99% southern potato wireworms. An average of 2.2 larvae per square foot to 6-inch depth were found; and 4.6% of the harvested potatoes from 12 farms showed wireworm feeding; 1.3% were sufficiently injured to be classed as "damaged."

6. Two-Spotted Spider Mite. At Beltsville, Md., two strains of the two-spotted spider mite, Cranbury-1 (parathion resistant) and Niagara (parathion susceptible), are being used to study biological activities that occur between strains. When virgin females of either strain mated with males of the same or opposite strain, resistance was transmitted to female offspring by either sex. When the mated females were exposed to males of the opposite strain for a second mating, Cranbury-1 females were not inseminated by the

second exposure. In contrast, Niagara females successfully mated a second time and resistance of their progeny indicated that the two matings were of equal importance. In mixed populations where the rate of Cranbury-1 to Niagara males was 1:1, Cranbury-1 virgin females showed a 9 to 1 preference for Cranbury-1 males over Niagara males and the Niagara females showed a 7 to 2 preference for Niagara males.

Cranbury-1 and Niagara females were placed on potted bean plants in proportions of 10 N - 0 C, 8 N - 2 C, 5 N - 5 C, 2 N - 8 C, and 0 N - 10 C. When tested at 5 intervals during the succeeding 10-week period, the mixtures of strains tended toward greater susceptibility at each sampling. Tests on progeny of individual mites revealed the presence of both homogeneous and heterogeneous individuals.

7. Mexican Bean Beetle. At Beltsville, Md., young virgin female Mexican bean beetles that had mated once produced fertile eggs for 4 to 5 weeks. When a virgin female was mated with an apholate-sterilized male, eggs did not hatch, but if remated with a normal male high fertility was restored to eggs laid subsequently. Egg fertility between weekly matings in which normal and sterilized males were alternated indicated a greater influence of the most recent mating but a holdover effect from earlier matings.

#### B. Insecticidal and Cultural Control

1. Cowpea Curculio. At Charleston, S.C., Bidrin, Bay 25141, Azodrin, and methyl parathion were the most promising of 12 compounds tested in field plots of southern peas for control of the cowpea curculio.

2. Squash Vine Borer. Carbaryl, naled, and endosulfan gave adequate protection to field plots of summer squash in South Carolina. Lindane was less effective but all materials controlled the pickleworm.

3. Cabbage Looper. At Charleston, S.C., of 45 experimental compounds compared in laboratory tests, nine showed sufficient toxicity to justify further study. In field tests seven were as effective or superior to naled and endosulfan on fall cabbage. On spring cabbage eight were as effective or superior to naled and endosulfan, and superior to mevinphos. Four, as used, were phytotoxic.

4. Southern Potato Wireworm. Thirty-four compounds were compared in laboratory tests in South Carolina for larval toxicity. The most promising were Dursban and Stauffer N-4328 and N-4988. In field-plot tests, Niagara NIA-10242 was the most promising material tested for southern potato wireworm control. Seven materials reduced larval populations 96% or more.

5. Leaf Miners. At Charleston, S.C., 28 compounds were tested for toxicity to leaf miner larvae in cowpea seedlings. Nine were promising for possible control.



6. Banded Cucumber Beetle. Of the 35 compounds tested in the laboratory at Charleston, S.C., six were somewhat effective against banded cucumber beetle larvae.

7. Sweetpotato Insects. Also at Charleston, S.C., Niagara NIA-10242, diazinon, Dursban, and Stauffer N-2790 were effective for southern potato wireworm control when applied as granules over the sweetpotato beds on July 15 and August 15 at 1.5 lb/acre of active ingredient on each date. One application of diazinon at 3 pounds on July 30 was less effective. Niagara NIA-10242 was the most effective against the Diabrotica-Systema complex but reduced injury only 50%. However, it was the only material tested which controlled sweetpotato flea beetle larvae.

8. Drosophila. At Beltsville, Md., technical malathion at 2 lb/acre showed promise for the control of drosophila on tomatoes. It was less effective than diazinon granules at 1 lb/acre but equal or superior to diazinon technical or malathion EC at 3/4 lb and 2 lb/acre, respectively. Malathion technical at 1 lb/acre gave poor control of drosophila.

9. Corn Insects. At Tifton, Ga., of the chemicals tested for control of corn earworm and fall armyworm, only Azodrin was significantly better than DDT. Niagara NIA-10242, Mobil MC-A-600, and Shell SD-7438 gave control equal to DDT.

Also at Tifton minimum improvement in control after treatment with DDT was found in sweet corn varieties resistant to the earworm. Maximum improvement in control was found in the susceptible varieties.

10. Mint Flea Beetle. At Forest Grove, Oreg., helicopter applications of low volume technical malathion on mint at rates of 6 and 8 ounces per acre reduced mint flea beetle populations 92% and 98%, respectively, for 14 days after application.

#### C. Insecticide Residue Determinations

1. Effect of Rain on Persistence of DDT on Sweet Corn. At Tifton, Ga., artificial rain was applied in 1-inch increments at rates of 0, 0.5, and 2.0 inches per hour to plots of sweet corn previously treated with DDT emulsifiable concentrate (2 lb DDT/acre). About 10% more DDT was lost from the higher rate of rainfall (2 in./hour) than from the lower rate (0.5 in./hour). The loss of DDT residues from the plot that received no artificial rainfall was much higher than expected, about 50% during the first day.

2. Chlorinated Hydrocarbon Residues in Farm Soils. Soil samples collected in October and November 1964 from 186 corn farms in the State of Iowa were analyzed at Beltsville, Md. Chlorinated hydrocarbon residues exceeding 0.01 ppm were found in soil from 74 farms. Aldrin was found in the samples from 34 farms, dieldrin from 61 farms, heptachlor or heptachlor epoxide from 15 farms, and DDT from 7 farms. The largest amount found was 1.8 ppm of aldrin

and 0.66 ppm of dieldrin in one sample. All but one grower indicated they had used chlorinated insecticides.

3. No Malathion and Diazinon Residues above Tolerance on Tomatoes. At Beltsville, Md., malathion and diazinon sprays were applied to tomato plants at approximately weekly intervals between September 3 and September 20, 1965. Samples for residue analysis were collected 24 hours after the first three sprays and 6 hours, 1 day, and 2 days after the final spray. The treatments were technical malathion, 1 and 2 pounds per acre; malathion emulsion concentrate, 2 pounds active per acre; technical diazinon, 0.75 pound per acre; and granular diazinon, 1 pound active per acre. No residues exceeding the established tolerances (diazinon, 0.75 ppm; malathion, 8 ppm) were found on tomatoes, even when samples were collected 6 hours after treatment.

At Beltsville, Md., an aerosol application of dichlorvos (10%) in methyl chloride applied to greenhouse tomatoes, cucumbers, and Bibb lettuce showed maximum residues of 0.24 ppm on lettuce and .02 ppm on tomato 1 hour after exposure. No detectable residues were found in 2-day or later samples.

Aerosols containing 10% sulfotepp showed residues of 0.20 ppm in lettuce, 0.12 ppm in tomato and 0.01 ppm in cucumbers 1 hour after exposure and 0.02 ppm in 7-day lettuce and tomato samples.

4. Tepa Residues. At Tifton, Ga., the GLC method was used to determine the persistence of tepa in fall armyworm moths after both sexes were fed 0.3% tepa in 10% aqueous sucrose. Moths ingested up to 100 µg and over 90 and 95% of the tepa had disappeared within 24 and 48 hours, respectively. About 1 µg of tepa per insect was recovered from the feces after 48 hours.

A felt wick insect feeding device continuously impregnated with 0.15% tepa and 2% aqueous sucrose was attached to ultraviolet light traps in the field. Samples of the solution and wick taken on the day of installation and after 1, 2, 3, and 5 days indicated that tepa in the aqueous sucrose solution declined approximately 45% during the first 24 hours, and leveled off at about 50% of the original quantity during the next four days. Tepa in the wick diminished 20% during the first 24 hours, 53% by the end of the second day, and 86% by the end of the third day where it leveled off.

5. Residues in Sweet Corn. At Tifton, Ga., gas chromatographic techniques for analyzing residues of Azodrin and Bidrin in raw extracts of sweet corn showed that amounts as low as 2 ppb were detected without appreciable interference from the corn extract. Imidoxan and Imidan in corn silage and in sweet corn were detected at levels of 2 ppb (parts per billion) for Imidan and 4 ppb for Imidoxan.

#### D. Biological Control

1. Cabbage Looper. At Mesa, Ariz., rearing of cabbage looper larvae field-collected throughout the year in the Salt River Valley of Arizona revealed



a high percentage of parasitism by the tachinid fly, Voria ruralis. Parasites reared in the Mesa laboratory on looper larvae were released in four 12 X 24 X 6-foot field cages, each containing 150 lettuce plants infested with 300 looper larvae. Ten, 50, and 175 pairs of introduced Voria adults parasitized 4%, 13%, and 57%, respectively, of the sampled larvae. None of the larvae in check cages was parasitized.

At Riverside, Calif., the presence of formaldehyde in the larval diet in laboratory studies reduced the infectivity of cabbage looper polyhedral inclusion bodies (PIB). This effect was manifested by a 53-fold increase in the LD<sub>50</sub> values as well as an increase of almost 2 days in the time to reach the LT<sub>50</sub> values. The susceptibility of cabbage looper postlarval stages to nuclear polyhedrosis virus infection gradually decreased until adulthood was reached. Moth infections were obtained by using free virus preparations. Histological studies of the moths in which polyhedral inclusion body preparations were fed or injected did not reveal the presence of infection. Infected progeny were obtained from moths fed polyhedral inclusion body suspensions. Injected moths did not yield infected progeny.

At Charleston, S.C., 3 weekly combination spray applications on field cabbage plots of cabbage looper nuclear polyhedrosis virus at 100 billion polyhedra per acre plus 1 qt/acre of commercial Bacillus thuringiensis liquid formulation were preceded by 1 application of the virus alone; on harvesting 50% of the plants were free from cabbage looper and fall armyworm injury and were classed ineligible for U.S. Grade 1 because of damage. In a comparable untreated planting 5% were free from damage and 52% were rejected for U.S. Grade 1. In 1966 spring-crop field tests, 6 weekly spray applications of the virus at 6 trillion polyhedra per acre plus 1 qt/acre of the B. thuringiensis formulation were as effective as an endosulfan-parathion mixture in control of imported cabbageworm and larvae of the diamondback moth, but less effective against the cabbage looper. In virus-bacillus sprayed plots 4% of the plants were ineligible for U.S. Grade 1 because of caterpillar damage, as compared to 2% in endosulfan-parathion mixture sprayed plots and 88% in untreated plots. The bacillus formulation alone did not give adequate control of looper.

In laboratory studies several commercial formulations of B. thuringiensis and the axenic cultures prepared therefrom were found to be at least partially repellent to larvae of the cabbage looper and the imported cabbageworm. Observations and field collections of cabbage looper larvae showed a high percent of natural infection by the fungus Spicaria rileyi. Eighty-one immature cabbage looper larvae were collected and held in individual vials for observation. Fifty-seven percent died as a result of the fungus and 5% were killed by larvae of the hymenopterous polyembryonic parasite Copidosoma truncatellum.

2. Pea Aphid Parasites. An experiment was conducted in the Walla Walla, Wash., area to determine whether overflooding of the pea aphid population in alfalfa fields with large numbers of parasites would prevent the annual

migration of this aphid to the more than 60,000 acres of green peas grown in adjacent areas. Approximately 100 million small wasplike parasites (Aphidius pulcher Baker) of the pea aphid were reared in heated plastic film-covered cages in alfalfa fields in the spring of 1966 and released. Production and release of parasites continued during spring and early autumn. The cages provided an abundance of parasites long before they would normally be available. The released parasites invaded approximately 15,000 acres of alfalfa. Pea aphid migration to peas was reduced to an insignificant level requiring no insecticidal treatment. The pea aphid spreads the destructive pea enation virus in pea fields and causes damage to peas by its feeding.

Approximately 22 million parasites per acre were raised on pea aphids in each of 18 plastic film-covered cages on a mixture of Atlantic and Vernal varieties of alfalfa. Buffalo, Ranger, and Caliverde alfalfa varieties were the most prolific of 30 tested for mass production of aphids for rearing parasites.

3. Banded Cucumber Beetle. At Charleston, S.C., 3 sprays of the parasitic nematode DD-136 were applied to field plots to give 2500 or 5000 nematodes per quart of soil to a 6-inch depth. Mortalities were 80 and 92%, respectively, of banded cucumber beetle larvae placed in samples of the soil 4 days after the last application decreasing to 28% for both dosages after 30 days.

4. Aphids. Collections of diseased aphids on different plant species in South Carolina revealed that several species of fungi of the genus Entomophthora are infecting and possibly influencing aphid abundance in the vicinity of Charleston.

5. Mexican Bean Beetle. In laboratory tests at Charleston, S.C., Metarrhizium anisopliae killed 100% of the first-instar larvae of the Mexican bean beetle after 72 hours. This fungus was not found to be pathogenic to the adult or egg stages of this insect.

6. Other Insect Pathogen Studies. Also in South Carolina, 6 fungi evaluated as pathogens against second instar banded cucumber beetle larvae were Metarrhizium anisopliae, Aspergillus ochraceus, Acrostalagmus aphidum, Entomophthora coronata, Entomophthora sp., and Cladosporium sp. Only Metarrhizium anisopliae displayed potential value as a control agent. Mortality observed was 5, 70, and 100% after 24, 48, and 72 hours, respectively.

7. Corn Earworm. Two commercial preparations of a Heliothis virus were compared in the laboratory at Charleston, S.C. Neither was highly toxic to corn earworm larvae. One gave 42.7% mortality after 10 days, the other 16.7%. Mortality in the untreated cages was 4.4%.

8. Corn Insects. At Tifton, Ga., preliminary results on the effects of temperature and dosage on the pathogenicity of the fall armyworm nuclear-



polyhedrosis virus indicated higher total larval mortality at 22-25° C than at 29-31° C. Peak and final mortalities occurred later at the lower temperature than at the higher temperature.

#### E. Insect Sterility, Attractants and Other New Approaches to Control

1. Cabbage Looper. The number of male cabbage looper moths caught increased with increasing numbers of virgin female moths confined in cages attached to blacklight traps in tests at Riverside, Calif. The mean numbers of males caught per night per 3 blacklight traps with 0, 12, 24, 48, or 96 virgin female moths were 12, 38, 100, 117, and 286, respectively. The number of female moths caught in the baited blacklight traps was not affected. When cages containing virgin females were placed (1) on the trap, (2) 40 feet away, (3) 80 feet away, or (4) 160 feet away from the trap, traps with caged virgin females on the trap or 40 feet from the trap caught significantly more male moths than unbaited traps or baited traps with the virgin females placed 160 feet from the trap. The regression of male catches on distance of virgin females from the trap indicates that the catch was reduced approximately 1 male per night per trap for each foot in distance the virgin females were placed away from the trap within the range of 0 to 160 feet. When marked males were released, 95% of the moths recaptured were caught in the virgin female baited traps.

To determine whether sex pheromone alone and/or other factors were involved in the attractiveness of the female baited blacklight traps, experiments were conducted with unmated cabbage looper males, virgin females with abdomens enclosed in gelatin capsules, equal number of males and females in a common cage, and virgin females alone. Traps baited with males or females with gelatin encapsulated abdomens were not as effective as virgin female baited traps. Mixed sex baited traps were as effective as virgin female-baited traps on the first night but effectiveness decreased thereafter.

Blacklight traps with 6- or 15-watt fluorescent lamps caught approximately equal numbers of male and female cabbage looper moths. Blacklight traps baited with virgin female moths caught more males than the unbaited traps. Traps with 15-watt fluorescent blacklight lamps and baited with virgin females caught nearly twice as many male moths as the 6-watt trap baited with virgin female moths.

At Riverside, Calif., the synthesized female cabbage looper sex pheromone was incorporated in a sand carrier in 100, 1000, 10,000, or 100,000  $\mu$ g amounts and tested for effectiveness in the field in combination with blacklight traps. Traps baited with 100,000  $\mu$ g of the synthesized pheromone caught 13 times more males than unbaited blacklight traps and about 2 times more than blacklight traps baited with 100 virgin females. At the end of 30 days, the former was still more effective than the latter. Traps baited with 100, 1,000, and 10,000  $\mu$ g were more effective than unbaited traps up to 9 days under field conditions.

At Charleston, S.C., an 8% concentration of apholate sterilized male cabbage looper moths when exposed for 15 minutes to dried residue on glass.

2. Cucumber Beetles. At Charleston, S.C., 126 fractions of extracts of 40,527 virgin female banded cucumber beetle abdomens were bioassayed as male attractants. Pollen was found to be a necessary ingredient in the diet of spotted cucumber beetles for the production of a male lure by the females. When crude extracts of spotted cucumber beetle and banded cucumber beetle females were mixed, male response of the former was decreased by about 50% and the latter showed no measurable activity. There was evidence that the residual half-life of the spotted cucumber beetle attractant on filter paper was less than 1 hour. This is in contrast to that of the banded cucumber beetle, which remains active for several days. Active extracts were obtained from spotted cucumber beetle females up to 24 hours after they had mated. Extracts from banded cucumber beetle females immediately after mating were inactive. No evidence of a sex attractant in the striped cucumber beetle was found.

Concentrations of 0.5 and 1% apholate in buffalo gourd extract sterilized males when they fed on the residues on filter paper or strips of fiber glass. A concentration of 0.25% was partially effective. Hydroxy urea at 1% was ineffective. General Chemical compounds 6936 and 8993 at 1% were highly toxic to males. An electronic flash was ineffective as a sterilant when males were exposed at a distance of 1.5 inches from a 1/1500 second flash.

3. Squash Insect Control. In South Carolina a soil mulch of reflective aluminum foil reduced by 82% the number of banded cucumber beetles that flew into a planting of yellow straightneck summer squash and reduced by 87% the number of seedlings showing their feeding. The number of aphids that flew into the field was reduced by 96%, the number of pickleworm-infested fruits by 72%.

4. Mexican Bean Beetle and Aphids. Overwintering adult Mexican beetle migrations to plots of snap beans were reduced 92%, 84%, and 51% when plots were mulched between rows with 2-foot-wide peg board covered with aluminum, titanium white paint, or dull black paint, respectively, in comparison to unmulched plots in tests at Beltsville, Md. Reductions of aphids caught in yellow water traps were comparable.

5. Trapping Studies. At Beltsville, Araujia sericifera flowers caught the same insect species as in 1964. Blacklight traps installed near the Araujia vines and 100 feet away, caught equal numbers of insects at both locations. Most of the insects were caught in the blacklight traps.

6. Drosophila. At Beltsville, Md., 2% apholate in bait on vermiculite broadcast over tomato plants in screen cages gave a maximum of 90% reduction over untreated controls. Approximately 72% of females collected from the apholate-vermiculite plots during the season were sterile. The vermiculite bait containing 2% apholate gave better control than 2% apholate on 1-inch



Oasis Foam cubes distributed 1 cube to every 4 feet of row but was not superior to tepa or ENT 50905 at the same concentrations on Oasis Foam cubes.

In laboratory screening tests at Beltsville, a bait containing 2% of the chemosterilant ENT 50905 gave high sterility of male Drosophila melanogaster adults for about 2 weeks; but was ineffective against female flies. A bait containing 1% apholate gave high sterility of both sexes for about 25 days.

#### F. Evaluation of Equipment for Insect Detection and Control

1. Southern Potato Wireworm. At Charleston, S.C., a 15-watt fluorescent blacklight trap caught 19,319 southern potato wireworm adults during 13 nights in August, significantly more than in traps with green, daylight, or strontium blue lamps. The last named lamp caught the least number of beetles. No significant differences were found between the catches of adults in blacklight traps placed 2, 4, 6, 10, or 18 feet above ground level. Overwintering larval populations of the southern potato wireworm were not significantly reduced in the soil within 100-foot radii around 15-watt blacklight traps operated throughout the preceding summer and fall.

2. Corn Insects. At Tifton, Ga., conventional insecticides applied every day gave better corn earworm control than insecticides applied every-other-day or every third day. Applications on an alternate day schedule were significantly better than applications made every third day.

Also at Tifton a tractor-mounted system for applying technical or concentrated formulations, at extremely low volumes was developed. One system is capable of applying the toxicant at rates as low as 1 pint per acre. The other system will apply toxicants as low as 1 quart per acre.

At Tifton, Ga., engineers have continued to refine a system utilizing air streams to separate insects on a weight and shape basis. Combined with an ultraviolet light trap, the unit increases the efficiency of the trap and can be used to collect desired species from the total night-flying population.

3. Helicopter Spray Studies. At Forest Grove, Oreg., water-based dye sprays were applied with a Bell 47D-1 helicopter using a 48-foot boom with 41 flat spray nozzles symmetrically arranged. The helicopter was flown at a height of 8 feet at speeds of 30, 42, and 54 miles per hour. Spray recovery data showed that when the speed of the helicopter was increased from 30 to 54 mph with the discharge rate remaining the same, the deposit rates on the top surfaces of target plates were reduced approximately one-half and on the under surfaces by about two-thirds.

Helicopter tests conducted in cooperation with the U.S. Forest Service, showed that where Douglas fir trees were sprayed at rates of 1 and 3 gal/acre with water-based dye sprays, the average recovery was .3 and .63 gal/acre, respectively, in the tree crowns. Recovery at the ground level among the trees was .14 and .6 gal/acre, respectively, at the two rates. Spray

coverage was most uniform at the 3 gal/acre rate, but the spray droplet size range was much greater. There was no significant difference in the amount of spray recovered at the top, middle, and lower crown positions within the trees.

Trees sprayed with a fluorescent tracer spray at 1 and 3 gal/acre had an average of 1.4 and 5.4 droplets deposited per 10 needles. Average deposits of the fluorescent tracer were 45, 30, and 25% of the total droplets at the top, mid-crown, and lower crown levels, respectively. During these studies Calcofluor white used with suitable recovery targets proved useful for evaluating spray patterns, distribution, droplet size, and foliage penetration.

Spray deposit spot sizes of the fluorescent at the 3 gal/acre rate ranged from 27 to 1410 microns with a mean of 456 microns and for the 1 gallon rate from 78 to 1210 microns spot size with a mean of 339. Results were similar with water-base dye sprays. There were fewer spots per unit area on the targets treated at the 1 gal/acre rate but proportionately more were in the mid-range of micron size than for the higher application rate of 3 gal/acre. These comparisons of the two application rates all seem to indicate that there would be a much higher percentage of droplets in the more useful size range at the lower rate.

In cooperation with the U.S. Forest Service a field test was conducted during the summer of 1965 to determine virus spray dosage and concentrations required for control of the Douglas-fir tussock moth. Three different virus polyhedra rates were applied by helicopter in 1-gallon and in 3-gallons of spray per acre. Spray was applied at 5 weekly intervals to potted trees, subsequently colonized with larvae to determine pathogenicity of the different treatments. Applications of 1, 5, and 50 billion polyhedra per acre in one gallon per acre were as effective, or slightly better, than applications of the same virus rates in three gallons per acre. The 50 billion polyhedra per acre rate was sufficiently effective to indicate a satisfactory control potential. All applications were most effective against second-instar larvae.

After the initial wave of polyhedrosis resulting directly from virus applications, waves of polyhedrosis occurred subsequently at about two-week intervals; apparently due to natural contagion and spread of the disease from those dying as a direct result of the virus applications.

#### H. Varietal Evaluation for Insect Control

1. Pepper Weevil. At Riverside, Calif., eighty-two selections from third generation crosses of wild vs. commercial type chili peppers were studied for resistance to pepper weevil attack. Individual pods from 25 plants from each of the 82 selections were examined for pepper weevil damage. Mean number of infested pods per selection varied from a low of 0.05 to a high of 16.60.



2. Leafhoppers. In preliminary studies in India (PL 480 Project A7-ENT-44) to determine the mechanisms involved in host plant resistance to certain leafhoppers of the genus Empoasca, castor bean plants, (Ricinus communis) were found most suitable for development of the leafhopper, E. kerri var. motti Pruthi, followed by cotton (Gossypium hirsutum) and potato (Solanum tuberosum) in that order. G. herboceum and G. arboreum were less suitable hosts of the leafhopper than cotton.
3. Two-Spotted Spider Mite. At Yakima, Wash., of 10 squash bug resistant hybrid lines of squash, two were very susceptible and two very resistant to attack by two-spotted spider mites.
4. Cabbage Looper. Field observations at Charleston, S.C., indicated S.C. Breeding Line 35 and Early Round Dutch cabbage to be least susceptible to cabbage looper feeding. Greenback, Steins Early Flat Dutch, Charleston Wakefield, S.C. Breeding Line 38, Red Acre, Marion Market, Jersey Wakefield, Midseason Market, Golden Acre, and Early Glory were an intermediate group, and Copenhagen Market No. 86 and Badger Market were most susceptible. The percentage of plants of these varieties showing serious injury by loopers ranged from 0 in case of S.C. No. 35 to 58.9 for Badger Market.
5. Soil Insects. L3-64 sweetpotatoes continued to be most resistant to soil insect attack of 40 varieties or breeding lines tested in the field at Charleston. Nemagold, also showed outstanding resistance to all of the soil insects present, except possibly the sweetpotato flea beetle. Several other breeding lines showed fairly high resistance, but all other commercial varieties were seriously injured. There was good agreement in the performance of lines that were tested in 1964 and 1965. Laboratory studies indicated at least two insect resistance factors in sweetpotato roots, one in the skin and another in the flesh. Either factor alone does not afford much protection in the field. There was evidence that the resistance factors were transient in at least some of the varieties.
6. Banded and Striped Cucumber Beetle. Also at Charleston, S.C., it was found that at least four of the cucurbitacins, a group of bitter compounds found in wild and cultivated cucurbits, are feeding stimulants for the banded cucumber beetle. These compounds elicit a strong biting response from the adult beetles when impregnated on filter paper and appear to be a major determining factor in preference shown by the insect for certain cucurbit crops and varieties. The striped cucumber beetle did not respond to the cucurbitacins tested on filter paper, and preliminary studies indicate there are other factors of greater importance as a basis for preference.
7. Drosophila melanogaster. Ripe tomatoes from 18 varieties were compared for their attractiveness to egg-laying adults of Drosophila melanogaster at Beltsville, Md. Higher number of eggs were laid in fruits of Pinkdeal, Manalucie, and High Crimson than in Roma, VF 13L, and VF 145B.

8. Leaf Miner. At Beltsville, Md., leaf miners showed a marked preference for oviposition in wild type tomatoes No. 128653 and No. 128655. The tomato types No. 126445 and 127826 were completely resistant to L. munda. No evidence of feeding or egg laying was noted for these two varieties even when placed alone in cages containing numerous adults.

At Beltsville, Md., of 33 tomato varieties tested when 8 weeks old, leaf miner larval survival in 26 varied from 91 to 80%. In the 7 remaining varieties larval survival was 74 to 80% in varieties No. VF 145B, Delshar, Floralon, and Kalohi; 64 to 68% in Chico and No 63B922; and 57 to 60% in Roma and Harvester. When 10 of the same varieties were retested as 10-week-old plants, larval survivals were 25, 27, 34, and 36% in Harvester, Chico, Roma, and No. 63B922, respectively. Larval survival of 94% in the primary leaves of nonresistant lima beans was a basis for comparing resistance in the tomato varieties.

9. Corn Insects. At Tifton, Ga., results showed that the husk, silks, and kernels contributed to the amount of insect feeding on kernels. Inbred 166 had good husk resistance for sweet corn but poor silk and kernel resistance. Inbred 245 had an extremely long husk but owes most of its resistance to silks. Inbred F-6 seemed to have good resistance in all three areas and transmits its resistance to progeny when used in hybrids. PI 217413 owes part of its resistance to the low survival of early instar larvae. Pollination of silks increased larval survival. Slitting the husk of pollinated ears further increased survival and average larval weights. Inbred 245 had significantly small larvae.

At Lafayette, Ind., cross and the reciprocal cross of the two inbreds most resistant to earworms produced the most resistant progeny in a diallel cross study. However, the cross and the reciprocal cross between the two inbreds most susceptible to earworms did not produce the most susceptible progeny.

At Tifton, Ga., of 20 sweet corn lines and 32 corn lines from South and Central America screened for leaf damage by fall armyworm larvae, some resistance was apparent in Zapalote Chico, Zapalote Grande, and Antiqua 2-D.

Diet utilization studies of lyophilized corn leaves, silks, and kernels by third instar fall armyworm and corn earworm larvae indicated a wide range in utilization of the lines screened. Fall armyworm larvae utilized only 21% of the leaves of inbred 360, while 42% of the leaves of inbred 230 were utilized. In general, the fall armyworm utilized corn leaves slightly better than the corn earworm. Results with the kernel diets indicated a difference ranging 20 to 50% for the fall armyworm and from 41 to 53% for the corn earworm. In general, there was a higher utilization of the diets by the corn earworm than by the fall armyworm. Kernels were more highly utilized than silks by both species of insects.

A larval arrestant and feeding stimulant extracted from kernels, silks, and leaves of selected lines of corn was screened for responses from corn earworm and fall armyworm larvae. Leaf extract had the most feeding stimulation for



fall armyworm and the least for earworm, while the kernel extract stimulation response was reversed. Silk extracts were intermediate for both species of insects.

Kernel extract on leaves seemed to give the highest level of holding ability for corn earworm larvae in a preliminary laboratory test, but silk and leaf extracts when placed on leaf substratum also significantly arrested motion and stimulated feeding. In contrast, the fall armyworm fed as readily on untreated leaves as on leaf surface treated with leaf, kernel, or silk extract, indicating that the maximum feeding response for this larva was already present in leaves.

Hickory tussock moth larvae were not stimulated to feed by kernel extract beyond the response to sugar. Toad flax extract did not elicit a strong feeding response from the corn earworm or fall armyworm.

Results of feeding stimulant tests with kernels with high (ae gene) and low (wx gene) amylose, low starch (super sweet), high and low protein, high and low lipids, and high and low carotene indicated that high amylose gave the highest feeding stimulant response for fall armyworm and corn earworm. Low amylose gave the smallest amount of feeding stimulant response for the fall armyworm.

Adding feeding stimulant to rearing medium increased fall armyworm larval weights and survival but did not effect corn earworm larvae.

## 1. Insect Vectors of Diseases

1. Aphids. Aluminum foil used as a soil mulch at Beltsville, Md., was superior to black polyethylene mulch or parathion spray in preventing infection of squash plants by watermelon mosaic virus. Flying aphids were reduced 93% over aluminum and 41% over black plastic as compared to the check during light aphid flights. After 11 weeks, percentages of virus infected plants were 4, 51, and 69 for aluminum, black plastic, and unmulched check, respectively.

During heavy aphid flights virus infection was delayed for several weeks by aluminum but not by parathion sprays. Yield of harvested squashes was about 6 times greater in mulched plots than in sprayed plots or the unmulched check.

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

### Basic Biology, Physiology, and Nutrition

- Burton, R. L., E. A. Harrell, H. C. Cox, and W. W. Hare. 1966. Devices to facilitate rearing of lepidopterous larvae. J. Econ. Entomol. 59: 594-6.  
Landis, B. J. 1966. Where does the green peach aphid come from? 5th Ann. Wash. State Potato Conf. Proc.: 59-64.

### Insecticidal and Cultural Control

- Douglas, W. A., and E. L. Moore. 1965. Chemical control of corn earworm in large plantings of sweet corn. Miss. Expt. Sta. Bull. 718.
- Landis, B. J., and J. A. Onsager. 1966. Wireworms in irrigated lands in the west: how to control them. Farmers' Bull. 2220. 14 p.
- Reid, W. J., Jr., and F. P. Cuthbert, Jr. 1966. Aphids on leafy vegetables-how to control them. Farmers' Bull. 2148 (Rev.)
- Young, J. R., and M. C. Bowman. 1966. Evaluation of Shell SD-8447 for control of two sweet corn insects. J. Econ. Entomol. 59: 170-3.

### Insecticide Residue Determinations

- Beroza, Morton, and M. C. Bowman. 1966. Apparatus and procedures for rapid extraction and identification of pesticides by single and multiple distribution in binary solvent systems. Anal. Chem. 38: 837.
- Bowman, M. C., M. S. Schechter, and R. L. Carter. 1965. Behavior of chlorinated insecticides in a broad spectrum of soil types. Agr. & Food Chem. 13: July/Aug.
- Bowman, Malcolm C., and Morton Beroza. 1965. Extraction p-values of pesticides and related compounds in six binary solvent systems. J. Assoc. Offici. Agr. Chemists. 48: 933-52.
- Bowman, M. C., H. C. Young, and W. F. Barthel. 1965. Minimal concentrations of aldrin, dieldrin, and heptachlor in soil for control of white-fringed beetles as determined by parallel gas chromatographic and biological assays. J. Econ. Entomol. 58: 896-902.
- Bowman, M. C., and M. Beroza. 1965. Analysis of Imidan colorimetrically and by electron-affinity gas chromatography. J. Assoc. Offici. Agr. Chemists. 48: 922-6.
- Harrell, E. A., M. C. Bowman, and W. W. Hare. 1965. An effect of electrostatic dusting on DDT dust deposition. J. Econ. Entomol. 58: 1016-7.

### Biological Control

- Featherston, Paul, E. and J. E. Halfhill. 1966. A portable field cage for mass culturing aphid parasites. ARS 33-113, 8 p.
- Hamm, John J. 1966. A modified azan staining technique for inclusion body viruses. J. Invert. Pathol. 8: 125-6.
- Young, J. R., and J. J. Hamm. 1966. Nuclear-polyhedrosis viruses in control of corn earworm and fall armyworm in sweet corn. J. Econ. Entomol. 59: 382-4.

### Insect Sterility, Attractants and Other New Approaches to Control

- Creighton, C. S., E. R. Cuthbert, Jr., and W. J. Reid, Jr. 1966. Fecundity of and hatch of eggs from banded cucumber beetles treated with three aziridines: preliminary tests. J. Econ. Entomol. 59: 163-5.
- Henneberry, T. J., A. F. Howland, and W. W. Wolf. 1965. Blacklight traps for control of cabbage looper. Electromagnetic Radiat. Agr. Conf. Proc. October: 34-5, 41.



- Henneberry, T. J., and A. N. Kishaba. 1966. Effects of some chemosterilants on the viability of eggs, fecundity, mortality, and mating of the cabbage looper. J. Econ. Entomol. 59: 156-9.
- Howland, A. F., P. Vail, T. J. Henneberry. 1966. Effect of chemosterilants on fertility of cabbage loopers. J. Econ. Entomol. 58: 635-7.
- Howland, A. F., P. Vail, and T. J. Henneberry. 1966. Results of cage experiments with sterile male releases and a chemosterilant technique for control of cabbage looper populations. J. Econ. Entomol. 59: 194-6.
- Jacklin, S. W., F. F. Smith, and A. L. Boswell. 1965. Egg mortality after gamma irradiation of adults of the omnivorous leaf roller. J. Econ. Entomol. 58: 1168-9.
- Young, J. R., and H. C. Cox. 1965. Evaluation of apholate and tepa as chemosterilants for the fall armyworm. J. Econ. Entomol. 58: 883-8.

#### Evaluation of Equipment for Insect Detection and Control

- Harrell, E. A., W. W. Hare, and J. R. Young. 1966. A fan for handling live insects. J. Econ. Entomol. 59: 756-8.
- Harrell, E. A., W. W. Hare, and J. R. Young. 1966. Ground equipment for applying low-volume insecticides to sweet corn. J. Econ. Entomol. 59: 487-9.

#### Varietal Evaluation for Insect Resistance

- McMillian, W. W., and K. J. Starks. 1966. Feeding responses of some noctuid larvae (lepidoptera) to plant extracts. Ann. Entomol. Soc. Amer. 59: 516-9.

#### Insect Vectors of Diseases

- Moore, W. D., Floyd F. Smith, G. V. Johnson, and D. O. Wolfenbarger. 1965. Reduction of aphid populations and delayed incidence of virus infection on yellow straight-neck squash by the use of aluminum foil. Florida State Hort. Soc. Proc. 78: 187-91.
- Smith, Floyd F. 1965. The role of color of reflected light in trapping and repelling transient aphids and reducing transmission of virus diseases. Report of conference relationships between arthropods and plant pathogenic viruses. U.S.-Japan Scientific Coop. Program (Supplement) Tokyo. Oct. 25-8: 62-70.

#### PUBLICATIONS - STATE EXPERIMENT STATIONS

- Brett, Charles H., C. L. McCombs, W. R. Henderson, and J. D. Rudder. 1965. Carbohydrate concentrations as a factor in the resistance of squash varieties to the pickleworm. J. Econ. Entomol. 58: 893-6. (N.C.)
- Canerday, T. Don. 1965. On biology of the harlequin bug, Murgantia histrionica Hahn (Hemiptera: Pentatomidae). Ann. Entomol. Soc. Amer. 93: 1-2. (Ala.)

- Chalfant, Richard B., and Charles H. Brett. 1965. Cabbage loopers and imported cabbageworms; feeding damage and control in western North Carolina. J. Econ. Entomol. 58: 28-33. (N.C.)
- Chalfant, R. B. 1965. Resistance of bunch bean varieties to the potato leafhopper and relationship between resistance and chemical control. J. Econ. Entomol. 58: 681-2. (N.C.)
- Chippendale, G. Michael, and Stanley D. Beck. 1965. A method for rearing the cabbage looper on a meridic diet. J. Econ. Entomol. 58: 377-8. (Wisc.)
- Chiykowski, L. N., and R. K. Chapman. 1965. Migration of the six-spotted leafhopper in Central North America. In Migration of the six-spotted leafhopper Macrosteles fascifrons (Stål). Wisc. Res. Bull. 261: 21-45. (Wisc.)
- Drake, D. C., and R. K. Chapman. 1965. Evidence for long distance migration of the six-spotted leafhopper into Wisconsin. In Migration of the six-spotted leafhopper Macrosteles fascifrons (Stål). Wisc. Res. Bull. 261: 3-20. (Wisc.)
- Hale, R. L., and H. H. Shorey. 1965. Systemic insecticides for control of western flower thrips on bulb onions. J. Econ. Entomol. 58: 793-4. (Calif.)
- Lichtenstein, E. P., G. Myrdal, and K. R. Schulz. 1965. Translocation of insecticidal residues from contaminated soils into five carrot varieties J. Agr. & Food Chem. 13: 126-31. (Wisc.)
- Mitchell, W. C. 1965. An example of integrated control of insects: status of the Southern green stink bug in Hawaii. Agr. Sci. Review 3(1): 32-5. (Hawaii)
- Shanks, Carl H. Jr., and R. K. Chapman. 1965. The use of antiviral chemicals to protect plants against some viruses transmitted by aphids. Virology. 25: 83-7. (Wash.)
- Shanks, Carl H. Jr., and R. K. Chapman. 1965. The effects of insecticides on the behavior of the green peach aphid and its transmission of potato virus Y. J. Econ. Entomol. 58: 79-83. (Wash.)
- Shorey, H. H., and R. L. Hale. 1965. Mass-rearing of the larvae of nine noctuid species on a simple artificial medium. J. Econ. Entomol. 58: 522-4. (Calif.)
- Sylvester, E. S. 1965. The latent period of pea-enation mosaic virus in the pea aphid, Acyrtosiphon pisum - an approach to its estimation. Virology. 25: 62-7. (Calif.)
- Sylvester, E. S., and J. Richardson. 1965. Aphid honeydew as inoculum for the injection of pea aphids with pea-enation mosaic virus. Virology. 25: 472-5. (Calif.)
- Wolfenbarger, Dan A. 1965. A sequential sampling plan for determining the status of corn earworm control in sweet corn. J. Econ. Entomol. 58: 651-4. (Tex.)
- Wolfenbarger, Dan A. 1965. Tomato, Lycopersicon esculentum, and Lycopersicon species and genetic markers in relation to mite, Tetranychus marianae, infestations. J. Econ. Entomol. 58: 891-3. (Tex.)



## POTATO INSECTS

Entomology Research Division, ARS

Problem. Control of insect pests is essential to the profitable production of high-quality potatoes. There is a continuing need for research to improve present control methods as insects develop resistance to insecticides and the public demands safer, more effective, and more economical methods of insect control. The overall problem is complicated in that many of the virus diseases of potatoes are transmitted by small populations of insects that otherwise would be of little importance. Sometimes it is not known which insects are responsible. It is important to learn the identity, distribution, and ecology of the vectors of diseases of potatoes in order to make an intelligent approach to the development of methods for preventing insect transmission of the diseases. There is an especial need for research on the ecology and biological control of potato insects; and for research on the evaluation of potato varieties for insect resistance. Growing concern over problems associated with insecticides which may also include residues in the soil, contamination of non-target areas, and interference with the work of natural enemies of insect and mite pests, requires that an increasingly strong research effort be concerned with development of non-chemical methods of insect control or of ways of using chemicals that will avoid objectionable side-chain effects.

### USDA AND COOPERATIVE PROGRAMS

Basic studies on the biology, ecology, and pathology of insects that attack potatoes in the field or transmit virus diseases, as well as applied research on their control are conducted by the Department at Yakima, Wash., Orono, Maine, Beltsville, Md., and Charleston, S.C., in cooperation with the respective State experiment stations, the Washington Department of Agriculture, the Washington State Potato Commission, and industry. In cooperation with the Crops Research Division studies on plant resistance are conducted at Ames, Iowa, under a grant to the Iowa State University of Science and Technology. Biological control studies at the University of Maine are conducted under a cooperative agreement.

The Federal scientific effort devoted to research in this area totals 4.6 scientist man-years. Of this number 0.3 is devoted to basic biology; 1.7 to insecticidal and cultural control; 0.7 to insecticide residue determinations; 1.2 to biological control; 0.1 to evaluation of equipment for control and detection; 0.3 to insects that spread potato diseases; and 0.3 to program leadership.

In addition Federal support of research in this area under grants and cooperative agreements totals 1.2 man-years. Of this total 0.7 is devoted to biological control and 0.5 to plant resistance to insects.

Research under the PL 480 grant program is being supported in India and Poland. Projects in India include research on hereditary variation in the ability of Myzus persicae to transmit potato leaf roll and virus Y (A7-ENT-33) and on physiological factors governing susceptibility or resistance of crop plants to leafhoppers (A7-ENT-44). In Poland research is underway on the influence of fatty acids and alpha-tocopherol on the lipid metabolism and physiology of the Colorado potato beetle and on vitamin activity in coming generations (E21-ENT-18).

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4.3 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Basic Biology, Physiology, and Nutrition

1. Aphids. At Presque Isle, Maine, aphid populations in 1965 were not large enough to reduce the total weight of tubers produced by untreated potatoes of the Katahdin or Kennebec varieties. However, the number of very small tubers (under  $1\frac{1}{2}$  in. diameter) was increased as a result of aphid feeding damage. Untreated Kennebecs substantially outyielded untreated Katahdins under competitive conditions.

Initial populations of the potato aphid in 1966 were average; however, an epizootic of entomogenous fungi occurred in August which greatly curtailed their potential development. The green peach aphid was more abundant than usual but buckthorn and foxglove aphids were scarce.

The number of aphid eggs in November 1965 on alder-leaved buckthorn, primary host of the buckthorn aphid, was the smallest on record since 1943. Colonies of green peach aphids were found in only 2 out of 26 thickets examined.

##### B. Insecticidal and Cultural Control

1. Aphids. At Presque Isle, two foliar applications of endrin made before the end of July reduced leaf roll in the Katahdin variety potatoes with 10% infector plants to only 1/9th that which occurred in untreated potatoes. This 2-spray treatment was far superior to one or two applications of UC-20047A at 0.25 or 0.5 lb./acre or plots receiving a planting furrow application of the systemic insecticide, disulfoton, at 1 lb./acre.

Best control of leaf roll spread from planting furrow applications of systemic insecticides was obtained with 0.5 lb./acre of disulfoton mixed with 0.5 lb./acre of Bay 25,141. Leaf roll spread from this treatment was only 0.6%, as compared with 1.6% from a seed dip of 2 or 4% Bidrin, 3.6% from 1 lb./acre of phorate, 3.2% from 1 lb./acre of Bay 25,141, or 4.2% from 1 lb./acre of disulfoton. The Bidrin dip injured the potato seed-pieces.



Single applications to potatoes , when 50-90% of the plants were aphid infested, of sprays containing UC-20047A at 0.5 lb./acre or a mixture of methyl parathion and endrin, each at 0.2 lb./acre provided aphid control, preventing yield loss. Two applications of methyl parathion were required to achieve approximately the same degree of aphid control.

From 92 to 99% control of the green peach aphid was obtained in 48 hours from single foliar application of RP-11974 at 0.2 or 0.4 lb./acre, methyl parathion-endrin mixture (each at 0.1 lb./acre), Bay 25,141 at 0.2 lb./acre or ethyl parathion at 0.1 lb./acre. The degree of control from most materials was slightly reduced at 6 days.

Field tests with potatoes at Yakima, Wash., showed that disulfoton gave better control of the green peach aphid when granules were placed in the soil below the level of the potato seed-pieces than above them.

2. Two-Spotted Spider Mite. Azodrin gave outstanding control of the two-spotted spider mite, Tetranychus urticae (Koch), on potatoes when applied with either ground equipment or with airplanes at Yakima. No residues were found in potato tubers harvested 21 and 32 days after foliage treatments were made.

Sprays containing Zinophos, phorate, and Union Carbide UC-21149 applied to large plants infested with the two-spotted spider mite with ground equipment gave 98% control of the mite for 14 days.

### C. Insecticide Residue Determinations.

1. No Organophosphorous Residues Found in Potatoes. Potato plots were sidedressed with granular formulations of diazinon at 2.8 lb./acre, parathion at 3.5 lb./acre, disulfoton at 4 lb./acre, or phorate at 3.3 lb./acre on May 3, 1965. Residues in the tubers were below the limits of sensitivity of the analytical method at harvest.

2. Chlordane Residues in Potatoes. Potato plots planted May 10 were sidedressed on June 4, 1965, with chlordane emulsifiable concentrate at the rate of 3 lb./acre. The residues in the tubers harvested on September 28 ranged from less than 0.01 to 0.13 ppm of chlordane. The average residue of 3 plots was 0.05 ppm.

3. Malathion Residues in Potatoes. Aerial sprays of undiluted technical (LV) and conventional dilutions of malathion (10 gal./acre), each at 12 ounces actual per acre, were applied to potatoes. The initial malathion residues on potato leaves from the dilute and LV sprays were 45.4 and 103.7 ppm, respectively; after 14 days these residues had decreased to 0.64 and 5.90 ppm.

4. Persistence of Organophosphorous Materials in Soils. At Yakima 8 granular formulations and 1 emulsifiable concentrate formulation of

organophosphorous insecticides were mixed with samples of virgin Sagemoor loam soil and subjected to weathering over a period of 8 weeks. Treated soil samples were bioassayed against wireworms and soils showing toxicity were analyzed for insecticide. The amounts of insecticide found in the soil initially and after 8 weeks were as follows: Granular parathion, 5.3 and 0.31 ppm; buffered granular parathion, 1.1 and 0.9 ppm; parathion emulsifiable concentrate, 1.1 and 0.8 ppm; granular Zinophos, 0.20 and 0.01 ppm (test period only 4 weeks); granular Stauffer N-2790, 0.27 and 0.08 ppm; granular Bay 37289, 0.66 and 0.49 ppm; granular Niagara NIA-10242, 2.7 and 0.72 ppm; granular Bay 25141, 2.5 and 1.7 ppm (test period only 6 weeks); and granular diazinon, 1.7 and 0.40 ppm.

5. Insecticide Content of Wireworm Larvae. At Yakima wireworm larvae contained 7.6 and 21 ppm of aldrin plus dieldrin, respectively, after exposure for 9 days to soils containing 1.25 and 2.50 ppm of aldrin. Analyses of larvae from the 7.6 ppm lot after exposure to insecticide-free soil for 7, 14, and 28 days indicated decreases to 4.0, 4.2, and 0.61 ppm of aldrin plus dieldrin, respectively. Analyses of larvae from the 21 ppm lot likewise exposed to insecticide-free soil indicated decreases to 18, 9.6, and 8.2 ppm. Analysis of the previously insecticide-free soil after the larvae had been kept in it showed 0.009 ppm of aldrin plus dieldrin.

#### D. Biological Control

1. Aphids. At Yakima, Wash., 6 kinds of syrphid flies were found preying on aphids on peach trees in the autumn of 1965. Syrphid larval activity was found on over half of the aphid-infested leaves; however, maximum stimulation for syrphid egg deposition was approximately 30-40 aphids per leaf.

The possibility of eliminating or markedly reducing populations of the green peach aphid and spread of leaf roll in potatoes by eradicating Canada plum, the primary host of the aphid, is being investigated at Presque Isle, Maine. Aphid population trends on untreated potatoes in isolated test areas of about 120 and 20 square miles are being studied. Canada plum in the 120-square-mile area will be destroyed with herbicides in 1966 and determinations of the compositions and trends of aphid populations will be made on potatoes in the test and check areas in 1967.

Parasitism of potato-infesting aphids on potatoes at Presque Isle was about the same level in 1965 as in 1964. Parasites reared from aphids on potatoes in 1964 showed that 39 percent of the primary parasites were parasitized by hyperparasites, an increase of 3 times as compared to 1962 data.

Coccinellid and syrphid aphid predators were slightly less abundant in 1965 than 1964 but spiders and chrysopids were more abundant. The coccinellids were 62% 13-spotted lady beetle, 18% transverse lady beetle, and 16% miscellaneous species. In former years the 13-spotted lady beetle has been present in trace numbers only.



Entomogenous fungi were found at Presque Isle slightly later in 1965 than in 1964, but the peak of abundance of dead diseased aphids came earlier and the epizootic was more complete in 1965. The effect of the fungi upon rate of aphid population growth was not apparent during the first 2 weeks after first occurrence but increased sharply thereafter. The delay in effect on aphid increase may be due to the shift in prevalence of the two most common species of fungi. Entomophthora aphidis was the most prevalent species initially but after 2 weeks E. thaxteriana became the predominant one. E. aphidis formerly was considered the more pathogenic; however, infections of E. thaxteriana may also affect the rate of aphid population growth. For the first time, in 1965 Entomophthora obscura was recovered from a dead diseased aphid on potatoes. Identification was made by I. Hall and J. Bell at Riverside, Calif.

Evidence obtained at Presque Isle in 1965 indicates that control of aphids on potatoes by natural agents is influenced by the size and border separations of the plantings. Aphid populations were larger and the seasonal peak was later in small fields of potatoes than in nearby small plots separated by oats or by bare fallow where diseased aphids appeared earlier. Parasitized aphids were more common in potatoes surrounded by oats than by bare fallow or in the small fields.

Entomogenous fungi appear to exert better aphid control in plots planted to potatoes every second year and surrounded by oats than in fields planted wholly to potatoes.

At Presque Isle, Maine, in 1965 in small plots and fields the results of studies to determine the effect on aphid potato populations of sustained releases of Coccinella septempunctata eggs or larvae or Chrysopa spp. larvae were masked by predator movement between plots so that treatment differences were not statistically significant. Oat- and aluminum-on-edge (in bare fallow land) plot separations prevented interplot movement of the aphids, but did not confine introduced predators.

In field cages and fields potato aphids became the dominant species where chrysopids were introduced, and the green peach aphid became dominant where the coccinellids were introduced.

The introduced predator Coccinella septempunctata L. overwintered as well in field cages over grassland in 1965-66 as in 1964-65, and in 1965-66 as well or better where no protection such as grassland inside the cages covered with several layers of burlap topped with a plastic cover was added.

Mass production techniques for parasites and predators of potato-infesting aphids are being studied under a cooperative agreement with the Maine Agricultural Experiment Station. As many as 3,000 C. septempunctata larvae per week were produced. Information on development under different environmental conditions now appears adequate for initiation of a mass-production program.

Experience in egg production indicated the need for methods to prevent or break diapause in beetles that overwinter in field cages at Presque Isle. Studies are underway with two parasites (1) Aphidius matricariae and (2) Praon spp. Thus far oviposition by these parasites has not been obtained.

#### E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Aphids. At Yakima, Wash., 8,761 peach trees were located and sprayed in April with a 275-mi.<sup>2</sup> control area upwind from the potato district. The program is designed to control the green peach aphid carrier of leaf roll disease and reduce spread of this disease in eastern Washington. The green peach aphid overwinters in the egg stage on peach trees. Aphids from colonies that develop after the eggs hatch move to potato fields. Estimates suggest the peach trees may contain 10,000 eggs per tree. Bi-weekly examinations of 60 aphid traps placed 4 miles apart downwind from the control area in May and June showed the area control program had delayed the spring flight of the aphids at least 6 weeks.

#### F. Evaluation of Equipment for Insect Detection and Control

1. Thrips and Mites. At Yakima, Wash., a counting board for use in detecting and evaluating populations of thrips and mites in the field was developed. It consists of a 9-square-inch piece of cotton filter cloth placed on a clipboard. The board is slipped under potato plant foliage. The plant is then struck 5 times with the hand. The method is useful for studying thrips populations and proved as accurate and much quicker for estimating mite populations than a mite brushing machine.

#### G. Varietal Evaluation for Insect Control

1. Aphids. At Presque Isle a study of 5 varieties of potatoes as breeding hosts of aphids indicated that Chippewa is a better host of potato or green peach aphids than Katahdins. Kennebec was a better host and Russet Burbank a poorer host than Katahdins for the buckthorn aphid. Chippewa was the only variety having a total-season aphid population larger than that on Katahdin.

#### H. Insect Vectors of Diseases

1. Aphids. In 1965 at Presque Isle as high as 90% control of leaf roll spread was obtained in plots where 10% of the potato stands were leaf roll reservoirs and green peach aphids were introduced to provide infestation. The plants were sprayed with 1/4% or 1/2% solution of chlorocholine chloride at 125 gal./acre of the spray mixture. Best control was obtained where the plants were colonized with aphids 1 week after the second of 2-weekly spray applications, and least control was where colonization occurred 1 week before spraying. There was little difference because of strength of the chlorocholine chloride in the spray. Most of the spread of leaf roll occurred during the first week after colonizing the plants with the green peach aphid.



Preliminary greenhouse studies indicated approximately 60% control of field spread of potato virus-Y after 3 or 6 applications of 2 gal./acre oil spray over a 6-week period to potato plants in replicated small plots. Stands of plants contained 5% disease plant reservoirs and were colonized with green peach aphids.

Aphid control in Katahdin and Chippewa potato, with 3% leaf roll reservoir plants, reduced the spread of disease to 1/16th of the spread where aphids were not controlled. Disease spread in untreated Chippewas was about 2 times as much as in untreated Katahdins, but only  $1\frac{1}{2}$  and 3 times that of reservoir plant abundance in Katahdin and Chippewa plantings, respectively. Near-perfect control of aphids and leaf roll spread followed a planting furrow application of disulfoton at 1 lb./acre.

At Simla (Punjab), India (PL480 Project A7-ENT-33), a study was initiated July 1, 1965, to detect and measure hereditary variation in the ability of the green peach aphid to transmit the potato leaf roll and Y viruses. Initially, emphasis was upon establishment of strains or pure lines of the aphid for use in the transmission studies. Six pure lines of the aphid were established and preliminary tests of virus Y transmission initiated.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

##### Basic Biology, Physiology, and Nutrition

- Landis, B. J. 1966. Where does the green peach aphid come from? 5th Ann. Wash. State Potato Conf. Proc.: 59-64.
- Powell, D. M., and B. J. Landis. 1965. A comparison of two sampling methods for estimating population trends of thrips and mites on potatoes. J. Econ. Entomol. 58: 1141-4.
- Wave, H. E., W. A. Shands, and G. W. Simpson. 1965. Biology of the foxglove aphid in the northeastern United States. USDA, ARS, Tech. Bull. 1338, 40 p.

##### Insecticidal and Cultural Control

- Bishop, Guy, B. J. Landis, A. G. Peterson, and Geddes W. Simpson. 1966. Recent advances in potato insect research. 1966 Hndbk., The Potato Assoc. of Amer.: 11, 34-45.
- Landis, B. J., and J. A. Onsager. 1966. Wireworms on irrigated lands in the West: How to control them. Farmers' Bull. 2220, 14 p.
- Landis, B. J., D. M. Powell, and J. A. Onsager. 1966. 1966 Potato insect calendar. 5th Ann. Wash. State Potato Conf. Proc.: 65-72.
- Onsager, J. A. 1966. Control of wireworms on potatoes with soil fumigants or insecticide band treatments. 5th Ann. Wash. State Potato Conf. Proc.: 13-5.
- Onsager, J. A., B. J. Landis, and H. W. Rusk. 1966. Control of wireworms on potatoes in eastern Washington by soil fumigants and organophosphorous insecticides. J. Econ. Entomol. 59: 441-3.

### Biological Control

Shands, W. A., G. W. Simpson, C. F. W. Muesebeck, and H. E. Wave. 1965. Parasites of potato-infesting aphids in northeastern Maine. Maine Agr. Expt. Sta. Tech. Bull. 19: 77 p.

### Insect Vectors of Diseases

Powell, D. M. 1966. The 1965 Columbia Basin potato growers aphid control program in relation to leaf roll spread and development of net necrosis. 5th Ann. Wash. State Potato Conf. Proc.: 65-72.

## PUBLICATIONS - STATE EXPERIMENT STATIONS

### Basic Biology, Physiology, and Nutrition

Hibbs, E. T. 1965. Solanum resistance to insects: Ecological concepts. Amer. Potato J. 42: 262.

Ladd, T. L., Jr., and W. A. Rawlins. 1965. The effects of the feeding of the potato leafhopper on photosynthesis and respiration in the potato plant. J. Econ. Entomol. 58: 623-8.

Rowe, P. R., and E. T. Hibbs. 1965. Solanum resistance to insects: Sources and evolutionary concepts. Amer. Potato J. 42(10): 297.

### Insect Vectors of Diseases

Bishop, Guy W. 1965. Green peach aphid distribution and potato leaf roll virus occurrence in the seed producing areas of Idaho. J. Econ. Entomol. 58: 150-3.



DECIDUOUS FRUIT, TREE NUT, GRAPE, AND BERRY INSECTS

Entomology Research Division, ARS

Problem. Insects and mites are important limiting factors in production of high quality fruits, nuts, grapes, and berries, shortening the profitable life of the trees, vines, or plants, and reducing the yield or quality of the crop. Certain insects and mites transmit diseases that adversely affect the life and productivity of the host plant. No one method of control is fully satisfactory and methods that are effective now may not be so later. At present biological, cultural, and other nonchemical methods of control are available for comparatively few insect pests. Much dependence is placed on insecticides for control. The continued use of insecticides, however, is complicated by the occurrence of insecticide-resistant strains of an increasing number of insects and mites, by the need to avoid objectionable residues on fruits and berries and on their waste products used for livestock feed, by their detrimental effects on beneficial insects, fish, and wildlife, and by contamination of non-target areas. There is a continuing need for research to develop more selective, economical, and safer insecticides; and for intensified research on alternate types of control such as those based on the use of attractants, repellents, traps, insect-resistant varieties and materials that affect insect growth and reproduction, including chemosterilants. More research is needed on integrated chemical-biological control programs with less intensive insecticide usage, so that the maximum benefits from parasites, predators, and pathogens may be realized. Research is required to determine more fully the role of insects in the transmission of important diseases affecting the production of these crops, and to determine host preferences, distribution, and habits of the insect vectors, and method of population suppression. Means must then be developed to reduce or eliminate the vector populations responsible for spread of the diseases.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving entomologists, chemists, insect physiologists, and insect pathologists engaged in both basic studies and practical solution of growers' problems. Research on pome and stone fruit insects is carried on at Yakima and Wenatchee, Wash., Vincennes, Ind., Wooster, Ohio, Kearneysville, W. Va., and Fort Valley, Ga., in cooperation with the respective State Experiment Stations. Research on insects and mites affecting pecan production is carried on at Albany, Ga., and Shreveport, La.; on insects affecting the production of grape, blueberry, and black walnut at Wooster, Ohio, in cooperation with the Ohio Experiment Station; and on strawberry insects at Beltsville, Md. Research on insects and mites in relation to the transmission of diseases of deciduous tree fruits is carried on at Riverside, Calif., Corvallis, Oreg., Wenatchee, Wash., and Fort Valley, Ga., in cooperation with the respective State experiment stations and the Crops Research Division. Work is also being

conducted under grants at the Washington, North Carolina, California, and Colorado Agricultural Experiment Stations, and at Brigham Young University in Utah.

The Federal scientific effort devoted to research in this area totals 19.5 man-years. Of this number 3.8 is devoted to basic biology and nutrition; 4.7 to insecticidal control; 1.9 to insecticide residue determinations; 1.3 to biological control; 4.9 to insect sterility, attractants, and other new approaches to control; 0.4 to evaluation of equipment for insect detection and control; 1.3 to insect vectors of plant virus diseases; and 1.2 to program leadership.

In addition Federal support under grants provides for a total of 4.8 professional man-years of research in this area. Of this total 2.0 is devoted to basic biology, physiology, and nutrition, 2.6 to insect sterility and attractants, and 0.2 to varietal resistance.

Research under grants of PL 480 funds (Projects E21-ENT-2 and 5) to the Institute of Pomology, Skierniewice, Poland, for studies of the differences in susceptibility and in cholinesterases in various species of spider mites, as influenced by acaricides and for studies on the biological control of mites, aphids, and scale insects on deciduous tree fruits and effects of pesticides on natural enemies has been completed. Studies are in progress by the Institute of Pomology, under PL 480 (Project E21-ENT-8) to study the mite fauna in Poland orchards with special reference to the relation between phytophagous and predaceous species. A portion of a grant of PL 480 funds (Project A17-ENT-5) to the Commonwealth Institute of Biological Control, Rawalpindi, Pakistan, for research on scale insects, fruit flies, and mites, and their natural enemies in West Pakistan is applicable to insects affecting deciduous tree fruits.

PL 480 projects recently initiated were: Israel (A10-ENT-13) on factors influencing variations in insecticide resistance, including resistance of codling moth to insecticides; Poland (E21-ENT-16) on population trends of predaceous arthropods in apple orchards sprayed with pesticides and the influence of these trends on population density of phytophagous mites and other pests; and Yugoslavia (E30-ENT-2) on leaf miners in orchards.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 50.2 scientist man-years is devoted to this area of research.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Basic Biology, Physiology, and Nutrition

1. Codling Moth. This insect is being successfully reared in large trays on an artificial diet at Yakima, Wash. Cannibalism proved to be density-dependent and could be regulated somewhat, thus obviating the necessity of



rearing the larvae in individual containers. Desiccation, the most troublesome aspect of rearing in large trays, was corrected by applying a thin coat of paraffin to the surface of the medium. Addition of sorbic acid and methyl p-hydroxybenzoate to the diet generally controlled fungus contaminants. Production costs are now estimated at \$4.80/1000. Facilities are being completed which will increase production to 2000/day.

Immersion of codling moth pupae in a 1 molar reagent grade of Cupriethylene diamine for 45-60 minutes was an effective treatment for mass removal of the silken cocoons without causing adverse effects on the insects. Shorter and longer immersion periods resulted in unsatisfactory cocoon dissolution and excessive mortalities, respectively.

Studies at Pullman, Wash., under a research grant revealed that the critical photoperiod for diapause of the Washington strain ( $47^{\circ}$  N) is longer (14.5 to 16 hours) than that previously shown in California ( $34^{\circ}$  N, 12 to 15 hours). A circadian oviposition rhythm is present, with peak oviposition occurring 3 hours prior to termination of the photophase.

2. Peach Tree Borers. At Vincennes, Ind., lesser peach tree borer adults would not mate or oviposit readily under artificial conditions because of their sensitivity to physical factors and disturbances. A special mating chamber was prepared to provide adequate natural lighting and supplemental artificial lighting for use on cloudy days with slow moving air heated to a constant  $85^{\circ}$  F being drawn into the chamber. Techniques have been developed to increase laboratory production of lesser peach tree borer on green thinning apples to about 7000 adults per month.

Emergence of peach tree borer moths varied from shortly before 8:00 a.m. until shortly after noon at Fort Valley, Ga. The mean times of emergence for 375 males and 381 females were 9:04 and 9:14 a.m., respectively. Adult female peach tree borers began emitting sex pheromone at an average time of 12:05 p.m. on the day of emergence. On subsequent days they began at an average time of 11:13 a.m. The females were most attractive to males on their second and third days of adulthood.

Research under a grant at North Carolina State University showed that peach tree borers could be reared on green thinning apples sufficiently well to provide larvae for testing synthetic diets. Larvae are developing well on one of the synthetic diets. Until a colony can be maintained year round, it will be necessary to obtain field-collected larvae for testing.

3. Plum Curculio. At Fort Valley, Ga., non-diapause plum curculio females that had mated in the fall produced as many larvae the following spring when held without males as those held constantly with males. Since the Central Georgia strain of plum curculio is largely non-diapausing and presumably carries large amounts of viable sperm overwinter, indications are that in a sterile male release program it would be necessary to compete with viable sperms already present in the females from the previous season's matings in addition to competing with normal males in the natural population.

Improvements in techniques for rearing plum curculio in Georgia have increased production to over 10,000 larvae per bushel of green thinning apples at a cost of about \$2.50 per bushel for the apples.

4. Pecan Insects. A study of the reproductive systems of the female hickory shuckworm moth at Albany, Ga., showed that in mated females the bursa copulatrix is enlarged and hardened; in unmated females it is flattened, opaque, and slightly folded near the center. Whether the moth has mated can be determined rapidly by grasping the vulva with forceps and pulling the bursa copulatrix out through the body wall.

During 5 days of confinement 24 of 58 female hickory shuckworm moths obtained from overwintering larvae collected in the fall and refrigerated at 32° F mated successfully. Male shuckworms mated more than once. Female moths preferred pecan leaves for oviposition rather than ridged plastic, paper, and tape.

In preliminary studies to develop an artificial diet for rearing hickory shuckworm, a diet containing ground sprouted pecans, soybean protein, Brewer's yeast, granulated sugar, Wesson salts, cholesterol, vitamin mixture (NBC), agar, and ascorbic acid appeared the most promising of six tested.

5. Insect Vectors of Virus Diseases. At Riverside, Calif., 13 species of eriophyid mites in orchard plant associations, 3 of which are important on pear or apple, and 2 from related pomaceous hosts, were named and described. The most significant of these, Eriophyes pseudoinsidiosus Wilson, an economic species which produces blisters on pear leaves, has obviously been present over a wide range for some time but never before taxonomically separated from the pear leaf blister mite, Eriophyes pyri.

Studies in California showed that incidence of diapause and body form of the adult pear psylla is governed by photoperiod. Diapause is induced particularly by the photoperiods experienced by the last 2 nymphal instars, but production of winter-forms is influenced by the photoperiod in earlier instars.

The minimum effective light intensity was approximately 0.2 foot candles, an intensity encountered somewhat before sunrise and after sunset. At 80° F, with cage-reared populations of pear psyllas from central and southern California, diapause was induced at about 14 or less hours of light per day for each strain.

At Wenatchee, Wash., in research under a grant, the sex ratio of pear psylla caught in a rotary net did not vary significantly from 1:1 throughout the season. Multiple mating is required for maximum egg laying. Preliminary observations indicate that overwintering adult psylla will mate in the fall but will not oviposit during photoperiods of 10 hours or less. Ovarian diapause is terminated by lengthening the photoperiod to 14 hours even though the adults have not been exposed to temperatures below 65° F.



6. Miscellaneous Insects of Deciduous Fruits. At Provo, Utah, in research under grant, collection of approximately 3,000 mites over a 6-month period indicated about 30 species inhabiting the trees and about 48 in the cover and soil beneath the trees.

At Wooster, Ohio, early larval instars of elder shoot borer, transferred from the host plant to artificial food media of the European corn borer, were reared to adults.

Laboratory rearing of the egg parasite, Trichogramma minutum, was increased to approximately 10,000 parasites per week with improved techniques at Vincennes, Ind. Increasing relative humidity within rearing chambers to 70-85%, at temperatures of 70-82° F, enhanced survival of immature Trichogramma to the extent that the percent emergence of adult parasites from codling moth eggs was increased from 40 to 78.

## B. Insecticidal and Cultural Control

1. Codling Moth. Codling moth was adequately controlled on apples by three applications of azinphosmethyl and one application of carbaryl in field tests at Kearneysville, W. Va.

2. Orchard Mites. At Wenatchee, Wash., there was evidence that McDaniel mites may have developed resistance to binapacryl. Laboratory bioassays of mites from an orchard with a history of treatment with binapacryl gave 17% mortality at a dosage equivalent to 0.5 pound actual per 100 gallons. Mortality of mites from an orchard with no binapacryl history was 92% at a dosage of only 0.03 pound actual per 100 gallons.

In laboratory screening tests at Yakima, Wash., two experimental materials gave 100% and 93% control, respectively, of two-spotted spider mites 3 days after application. In orchard tests four experimental materials were effective against McDaniel mites and three against European red mites.

Airplane applications of undiluted technical malathion (LV) to apple orchard plots reduced the population of McDaniel mites to one-third of that in another plot where a conventional air application of dilute malathion (10 gal/acre) was made. Both applications provided 4 pounds actual toxicant per acre. Within 10 days the mite populations in both plots doubled, whereas there was a slight decrease in population during the same period in a third plot sprayed with Kelthane.

In laboratory tests at Vincennes, Ind., both foliar and systemic applications of Ortho-9006 controlled two-spotted spider mites on lima beans. Foliar sprays of Mobil MC-327 also gave excellent control.

Studies in Poland (PL 480 project E21-ENT-5) showed that two spray applications in one season reduced to low numbers the orchard mites, Bryobia rubrioculus and Panonychus ulmi. Extremely cold winter temperatures

greatly reduced the overwintering stages. Late spring freezes also reduced populations and the need for spraying. Clean culture in an orchard growing on *Festuca* sod had no effect on Bryobia mite populations.

In other studies conducted in Poland (PL 480 project E21-ENT-2) dormant tar wash sprays applied in late autumn were less deleterious to scale predators than late spring treatments with the same material.

3. Pecan Insects. At Albany, Ga., 3 or 5 applications of parathion at 0.3 pound actual per 100 gallons were inferior to the standard treatment of 3 applications of EPN at 0.5 pound actual per 100 gallons for control of hickory shuckworm on Farley pecans. Five applications of parathion were no better than 3 applications. Three or 5 applications of malathion at 0.75 pound actual per 100 gallons were less effective than the parathion treatments.

Triphenyl tin hydroxide and carbaryl applied as 4x concentrate sprays at the respective rates of 1.6 and 4 pounds actual toxicant per 100 gallons on large pecan trees of the Schley variety controlled pecan weevil infestations with no detectable difference in their effectiveness.

Triphenyl tin hydroxide at 0.1 or 0.2 pound actual per 100 gallons applied to pecan trees of the Farley variety gave 95% control of the nut casebearer, whereas the standard, parathion, applied at 0.3 pound gave almost complete control.

At Shreveport, La., azinphosmethyl applied with an air blast ground sprayer gave almost complete control of the mite, Oligonychus viridis. Undiluted technical malathion (LV) applied by air at the rate of one pound per acre was ineffective.

Aerial applications of undiluted azinphosmethyl EC at the rate of 0.5 pound actual per acre, or conventional dilutions of azinphosmethyl at 1 pound actual in 6 gallons of water per acre were evaluated for control of nut casebearer. Nut cluster infestations that developed were as follows: Conventional dilute spray 5%, LV spray 14.5%, and the untreated check 20.5%.

Methyl demeton painted on the trunks of 5 year old pecan trees reduced infestations of yellow aphids to 0.24 aphids per leaflet, compared to 3.3 aphids per leaflet on untreated trees 2 weeks after treatment.

An aerial application of parathion at 1 pound actual in 20 gallons of water per acre effectively controlled the black pecan aphid.

4. Miscellaneous Insect Pests of Deciduous Fruits. In orchard tests against pear psylla at Yakima, Wash., Imidan was as effective as Perthane EC, the standard. Three superior type oils of 57, 60, and 140 viscosities were somewhat less effective than Perthane but held the psylla population below injurious numbers throughout the season.



Airplane applications of undiluted technical Perthane to Bartlett pears as a prebloom spray gave excellent control of pear psylla. Similar applications of malathion and azinphosmethyl failed to give adequate control.

Temik 10% granular, broadcast over the root area of 10-inch diameter pear trees at 1, 2, and 3 ounces per inch diameter of tree trunk, controlled pear psylla as effectively as sprays of Perthane.

At Fort Valley, Ga., several insecticides applied in combination with 2% superior oil before leaf fall or with 3% dormant oil during November and December failed to give adequate control of adult white peach scales. The best control, 60-70%, was achieved with parathion or azinphosmethyl combinations.

Matacil and endosulfan give outstanding control of the lesser peach tree borer and were significantly better than DDT plus parathion at Kearneysville, W. Va.

At Wooster, Ohio, 3 spray applications of carbaryl plus malathion gave excellent control of a blueberry tip borer when sprays were properly timed and properly applied.

Bait sprays of vegetable protein hydrolysate and malathion gave acceptable control of apple maggot and blueberry maggot in Ohio when sprays were started early, intervals between sprays were not too long, spray mixtures were at the proper concentration, and properly applied.

Carbaryl sprays in 2 applications gave satisfactory control of eriophyid mites on butternut trees. Timing of the first spray was important.

Properly timed sprays of carbaryl, lindane or delayed dormant oil sprays gave acceptable control of the hickory gall aphid.

### C. Insecticide Residue Determinations

1. Codling Moth. At Yakima, Wash., aerial sprays of undiluted technical (LV) malathion at 4 pounds actual toxicant per acre left initial residues on apple and pear leaves 1.3 and 1.4 times higher, respectively, than the conventional dilutions. After 14 days the apple and pear leaves had lost 86.0 and 78.1%, respectively, of the initial residues from the low volume treatment, while the loss from the dilute sprays was 90.7 and 97.7%. There was no significant difference between the drift characteristics of the two formulations. Thirty percent of the malathion applied by the low volume technique reached the ground compared with 24% of that applied in water.

Granular Temik broadcast on the soil surface under pear trees at 0.1 pound actual toxicant per tree and washed into the soil with 25 gallons of water resulted in no residues in leaves or twigs up to 145 days after treatment except in one leaf sample taken 56 days after application. This sample

contained 0.15 ppm of residue. Soil samples contained residues of 7.22 ppm at the time of application and 0.63 ppm 91 days later. Soil taken 163 days after the application and pears sampled at harvest time, 125 days after the treatment, contained no detectable residues.

#### D. Biological Control

1. Codling Moth. Eggs produced by normal female codling moths mated with males treated with 42 kr of gamma radiation were about 98% sterile. When eggs from such a mating were exposed to adults of the egg parasite, Trichogramma minutum, 84% of the eggs sustained an  $F_1$  generation of T. minutum. In a comparable test in these studies at Yakima, Wash., 95% of the eggs from normal parents sustained an  $F_1$  generation of the parasite.

2. Peach Borers. During the spring and early summer more than 10,000 lesser peach tree borers and over 450 American plum borers emerging from about 16 cords of heavily infested peach wood placed in screened cages were collected at Vincennes, Ind. The American plum borers were used to start a laboratory culture. Ninety-three braconid and 54 ichneumonid parasites were also collected. In parasite-host exposure chambers several successful parasitizations of the two boring insects occurred. Seven females and 1 male of Devorgilla sp. and 1 female Pimpla annulipes, both ichneumonid wasps, were reared from egg to adult stage under laboratory conditions. The former species was reared on larvae of the American plum borer, while the latter's host was a lesser peach tree borer larva.

When placed in a rearing chamber with approximately 1,000 Trichogramma minutum adults, 83 of 121 eggs of the American plum borer were parasitized and 123 T. minutum emerged -- an average of about 1.5 parasites per parasitized egg.

3. Red Banded Leaf Roller. At Vincennes, Ind., a laboratory population of Trichogramma minutum which has been maintained on codling moth eggs is now also being reared continuously on red-banded leaf roller eggs. Trichogramma is known to parasitize the genus Argyrotaenia but no records have been found to indicate that it parasitized the red banded leaf roller, species A. velutinana

Weekly field applications of Thuricide TS, a flowable formulation of the pathogen Bacillus thuringiensis, at dosages of 2, 4, 8, or 16 ounces of formulation per tree, reduced the percent survival of red-banded leaf roller larvae. The reductions ranged from 25% at the 2-ounce dosage to 69% at 16 ounces.

4. Miscellaneous Insects of Deciduous Fruits. In studies of predaceous mites in Poland (PL 480 project E21-ENT-8), phytoseiid mites in deciduous fruit orchards were greatly reduced when prolonged rains were followed by low winter temperatures. Similar mortalities of mites were obtained at low temperatures in laboratory experiments.



Typhlodromus findlandicus mites brought into the laboratory from hibernation fed on eggs and nymphs of Tetranychus urticae with no apparent preference but favored tarsonemid mites less for food. This predaceous mite laid fewer eggs and had a shorter life span if removed from hibernation before normal emergence in May.

#### E. Insect Sterility, Attractants, and Other New Approaches to Control

L. Codling Moth. A pilot test was started in 1966 at Yakima, Wash., to determine the usefulness of releases of sterile codling moths as a method for commercial control of this important pest of apples. The moths are sterilized by treatment with the chemosterilant tepa, or by gamma radiation, and released in a 15-acre apple orchard at a ratio of about 400 sterile to 1 wild male moth. The test orchard is located within an intensively cultivated apple-growing area in which normal spray operations conducted for control of codling moth provide a minimum of opportunity for large-scale influx of wild moths into the test block.

In trapping studies in Washington to determine dispersal of codling moths, 26 native and 5 sterile moths were captured in a single trap 1 mile from an apple orchard where sterile male moths were being released, and 107 native and 28 sterile moths were captured in 3 traps  $\frac{1}{2}$  mile from the release orchard. No other orchards were located within 1 mile of these traps, indicating that dispersal of codling moths may be greater than generally believed.

In other tests within a release orchard during late summer, nearly 5 times as many moths were captured in traps hung 10 feet above ground level as in traps hung at 4 feet.

Codling moth catches in blacklight traps and traps baited with virgin females were not significantly different. The seasonal mean daily catch of native moths was 1.8 per light trap and 2.0 per sex attractant trap. Combination light and sex attractant traps did not enhance codling moth catches as has been the case with certain other lepidopterous insects. In an orchard involving releases of sterile males, the mean daily catch of released plus native moths between June 23-July 6, in sex attractant traps was 29.9 males/trap and that in the combination light-sex attractant traps was 30.5 males/trap. Sex attractant trap catches exceeded those in other traps when the weather was cool but light trap catches were highest in hot weather.

2. Peach Tree Borers. At Vincennes, Ind., a novel experiment was started to determine the feasibility of suppressing populations of lesser peach tree borers by trapping males in sticky traps baited with virgin female moths. Sixty traps, each baited with 2 virgin females which were replaced on alternate days, were distributed in a 45-acre (3488 trees) peach orchard, considered to be almost free of borer infestation. The orchard was at least 5 miles from the nearest commercial peach orchards but the buffer zone

surrounding the test orchard contained approximately 700 backyard trees and an undetermined number of wild host trees. By late spring a total of 1457 male lesser peach tree borers were trapped. No female moths were trapped and no infestations had developed in the test orchard as of July 1.

Filtrates and extracts of whole bodies and of excised abdominal tips of virgin female lesser peach tree borers placed in acetone were attractive to males when bioassayed in 7.5 ft<sup>3</sup> outdoor screen cages in Indiana. When sticky traps were baited with equivalents of each material and placed in cages with 200 males, as high as 66.5% of the males were captured. Males responded to both filtrates and extracts but those prepared from whole females elicited the greatest response. Most of the males were caught during the first 20 minutes, but the filtrate remained potent for about 2½ hours. Stock materials were potent when exposed after storage of at least 48 hours.

In preliminary trapping studies at Fort Valley, Ga., 35 male peach tree borers were caught by 5 sticky traps baited with 2 or 3 virgin females. Approximately 2/3 of all males that investigated the traps were caught.

3. Pear Psylla. Adult male pear psyllas were sterilized when caged in the laboratory on pear foliage that had been dipped in a 3% solution of tepa and then dried at Riverside, Calif. After exposure to treated foliage for as long as 22 hours, the males mated readily with normal virgin females. Twenty-nine of 31 females mated to treated males laid infertile eggs; the infertile lots included 654 eggs. In the 2 instances when the males were not completely sterilized, 63 eggs were laid, of which 19% hatched.

Blacklight, blacklight B (visible light filtered), green, and white light were attractive to adults of the pear psylla in preliminary laboratory experiments at Riverside, Calif. In more than 100 tests involving groups of 10 insects per test introduced into a darkened chamber with the test-light source at one end, the lights attracted 37 to 67% of the psyllas placed in the chamber. When the insects were furnished choices between 2 colors, the blacklight was the most attractive. Red and yellow lights were not attractive.

4. Pecan Insects. Acetone extracts of female pecan nut casebearer and female pecan leaf casebearer moths failed to attract male moths to sticky board traps in pecan orchards in Georgia.

5. Miscellaneous Insect Pests of Deciduous Fruits. In blacklight trapping studies under a grant at Grand Junction, Colo., male and female oriental fruit moths were trapped in nearly equal numbers. Of 1409 females captured, 4.3% had not mated, 89.9% had mated once, 5.0% had mated twice, 0.78% had mated 3 times, and 0.07% had mated 4 times. A laboratory culture of the oriental fruit moth was established from a local peach source, but rearing problems have prevented a large increase in this culture.



In studies at Berkeley, Calif., under a research grant, males of the navel orangeworm were attracted to the female moths. Females 0-1 day old were the most attractive. A methylene chloride extract of female abdominal tips elicited some male response. Irradiation of pupae at a dosage of 60 kr resulted in approximately 99% non viable eggs. Optimum dosage for adult sterilization was 40-50 kr.

At Wooster, Ohio, yellow-colored sticky board traps were more satisfactory in trapping apple maggot or walnut husk maggot adults than colors ranging from orange to red. Sticky board traps, baited with 3 types of vegetable protein hydrolysates as well as with ammonium carbonate, gave no significant differences in the catch of adult flies of the walnut husk maggot.

## 1. Insect Vectors of Diseases

1. Pear Decline. Additional positive readings in vector tests with pear decline disease in California added substantially to the concept that pear decline is caused by a virus and is transmitted by the pear psylla.

Workers in other agencies in California recently described a disorder termed pear leaf curl, a disease of unknown cause but found in association with pear decline and threatening losses possibly greater than those resulting from pear decline. The symptoms thus far determined consist of a downward curling of leaves and purplish coloration of foliage. They appear only during a few weeks just prior to autumn leaf drop. Fruit yield of affected trees reportedly may be reduced by as much as 80%. Pear leaf curl affects trees of all rootstocks observed, whereas pear decline affects mostly trees on oriental rootstock.

In vector tests with pear decline inoculum and pear psylla at Riverside, at least 10 cases on recipient trees were diagnosed as pear leaf curl rather than the expected pear decline; check trees remained normal. Further tests under closely controlled conditions will be required to substantiate this development.

2. Miscellaneous Stone Fruit Virus Diseases. In further cooperative studies of a new, damaging, rapidly spreading virus of cherry at Corvallis, Oreg., virus obtained from infected sweet cherry reacted with cucumber mosaic anti-serum, indicating that this virus is a strain of cucumber mosaic virus; this hypothesis is supported by the aphid transmission, with a lack of vector specificity. The virus has now been transmitted by 10 species of aphids including Acyrtosiphon pisum (Harris), Aphis craccivora Koch, Aphis pomi DeGeer, Brachycaudus cardui (L), Macrosiphum californicum Clarke, Macrosiphum rosae (L), Myzus cerasi (F.), Myzus lythri (Schrank), Myzus persicae (Sulz.), and Pentatrichopus sp.

The virus was retained less than 1 hour by feeding aphids.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Basic Biology, Physiology, and Nutrition

- Cleveland, M. L. 1965. Maintenance of fruit insect cultures at Vincennes, Indiana. Ind. Acad. Sci. 75: 219-21.
- Tedders, Walker L., Jr. 1965. The biology and effect of two miridae on pecan nut drop in southwest Georgia. Proc. Southeastern Pecan Growers' Assoc. 58: 34-6.

Insecticidal and Cultural Control

- Calcote, Vernon, Walker L. Tedders, Jr., and Max Osburn. 1965. Control of pecan leaf casebearer and hickory shuckworm on pecan. Proc. Southeastern Pecan Growers' Assoc. 58: 45-7.
- Gilmore, J. E. 1966. Insect control. Amer. Fruit Grower. 86(2): 13-5, 50.
- Hamstead, E. O. 1966. Reduction in reproductive capacity of European red mite by Niagara 9203. J. Econ. Entomol. 59: 481.
- Harries, F. H. 1965. Control of insects and mites of fruit trees by trunk injection. J. Econ. Entomol. 58: 631-4.
- Harries, F. H. 1966. Reproduction and mortality of the two-spotted spider mite on fruit seedlings treated with chemicals. J. Econ. Entomol. 59: 501-6.
- Osburn, Max, and Walker L. Tedders, Jr. 1966. Control of the hickory shuckworm and the pecan weevil. Proc. Southeastern Pecan Growers' Assoc. 59: 96-100.

Insect Sterility, Attractants, and Other New Approaches to Control

- Butt, B. A., and D. O. Hathaway. 1966. Female sex pheromone as attractant for male codling moths. J. Econ. Entomol. 59: 476-7.
- Gilmore, J. E. 1966. Insect control. Amer. Fruit Grower. 86(2): 13-5, 50.
- Harries, F. H., and W. Gordon Wiles. 1966. Tests of some antibiotics and other chemosterilants on the green peach aphid. J. Econ. Entomol. 59: 694-6.
- Hathaway, D. O. 1966. Laboratory and field cage studies of the effects of gamma radiation on codling moths. J. Econ. Entomol. 59: 35-7.
- Tedders, Walker L., and Max Osburn. 1966. Blacklight traps for timing insecticide control of pecan insects. Proc. Southeastern Pecan Growers' Assoc. 59: 102-6.

Insect Vectors of Diseases

- Pollard, H. N. 1965. Fecundity of Homalodisca insolita, a leafhopper vector of phony peach virus disease. Ann. Entomol. Soc. Amer. 58: 935-6.
- Pollard, H. N. 1965. Description of stages of Homalodisca insolita, a leafhopper vector of phony peach virus disease. Ann. Entomol. Soc. Amer. 58: 699-702.
- Wilson, N. S. 1966. New species of eriophyid mites from western North America, with a discussion of eriophyid mites on populus. Ann. Entomol. Soc. Amer. 59: 585-99.



## CITRUS AND SUBTROPICAL FRUIT INSECTS

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Problem. Insects and mites that attack citrus and subtropical fruits reduce yield, lower quality, spread plant diseases, contaminate the marketable product, and increase cost of production. There is a continuing need for research to secure biological and ecological information on these pests that will provide a better basis for the development and implementation of insect control methods than that now available, or suggest additional non-chemical approaches to their control. Additional research is needed on biological control agents, including parasites, predators, and pathogens, and on methods for more effectively integrating biological, chemical, and other control measures. Safer, even more effective and economical control procedures that will minimize or avoid objectionable chemical residues and problems associated with residues should be developed. Research on attractants, chemosterilants, sterilization techniques, and genetic methods need increased attention. Protection against introduction into the United States of tropical fruit flies or other foreign injurious insect species requires effective low-cost detection methods, processes for destroying insect infestation in fresh fruits and vegetables intended for shipment to uninfested areas and eradication procedures for use in emergency situations to eliminate incipient insect infestations.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving both basic and applied research on insects and mites infesting citrus and subtropical fruits and on treatments for control of insects and related pests in commodities regulated by plant quarantines. This program is carried on at Beltsville, Md., Honolulu and Hilo, Hawaii, Riverside, Calif., Orlando, Fla., and Weslaco, Tex., in cooperation with entomologists, chemists, and agronomists of the respective State Experiment Stations; also at Orlando, Fla., in cooperation with the Crops Research and Plant Pest Control Divisions; at Hoboken, N.J., in cooperation with the Plant Quarantine Division; at Mexico City, Mex., in cooperation with the Plant Pest Control Division and with the Direccion General de Sanidad Vegetal of the Mexican Secretaria de Agricultura y Ganaderia, and on the islands of Guam and Rota in cooperation with the Territory of Guam, U.S. Navy, and the Trust Territory of the Pacific Islands. Work initiated in 1964 in San Jose, Costa Rica, on the Mediterranean fruit fly with funds supplied by the Agency for International Development (AID) in cooperation with the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), and with the Interamerican Institute for Agricultural Sciences at Turrialba, Costa Rica, was terminated at the close of 1965.

The Federal scientific effort devoted to research in this area totals 22.3 scientist man-years. Of this number, 3.6 is devoted to basic biology, physiology, and nutrition; 2.2 to insecticidal control; 0.4 to insecticide residue determination; 3.0 to biological control; 7.6 to insect sterility,

attractants, and other new approaches to control; 3.4 to insect control treatments for commodities regulated by plant quarantines; 0.1 to varietal evaluation of insect resistance; 0.7 to insect vectors of diseases; and 1.3 to program leadership.

In addition, Federal support of research in this area under grants and cooperative agreements totals 0.4 man years. Of this total 0.1 is devoted to biological control and 0.3 to insect attractants.

PL 480 research grants include India (A7-ENT-26), Biology of gall midges affecting mangoes with special reference to extent of damage; India (A7-ENT-35), Biology of gall midges affecting citrus plants with special reference to the extent of damage; Pakistan (A17-ENT-5), Studies on scale insects, fruit flies, and mites and their natural enemies in West Pakistan; Greece (E11-ENT-1), Control of the olive fly with radiation or chemical sterilization procedures; Egypt (F4-ENT-3), Induced sterility in males of Mediterrean fruit fly as a means of controlling and eradicating that pest.

New PL 480 projects recently initiated include grants for research in India (A7-ENT-47) on biology of gall midges affecting figs with special reference to the extent of damage; and in Israel (A10-ENT-13) on factors influencing variations in insecticide resistance, and (A10-ENT-15) on the ecology, biology, and control of the citrus bud mite (Aceria sheldoni, Eriophyidae).

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 28.9 scientist man-years is devoted to this area of research.

#### PROGRESS--USDA AND COOPERATIVE PROGRAMS

##### A. Basic Biology, Physiology, and Nutrition

1. Citrus Insects and Mites. California red scale males in free flight within an 8 x 12 x 8-foot room were attracted to caged virgin females on a turntable in studies conducted at Riverside, Calif. The ratio of males attracted to lemon cages containing 25 virgin females versus lemons without females varied from 100:1 to 300:1. Virgin females were most attractive to males when 4 to 5 weeks old. Attractive virgin females exposed to mating one afternoon became totally unattractive to males by the next afternoon.

When reared at 80° F, about 88% of the adult males of a given generation of California red scales emerged within 3 days after emergence began. During August, daily emergence began between 3:30 and 5:00 PM at illumination levels of 700-1000 ft-c and practically ceased at 8:00 PM when the illumination level had dropped to approximately 1 ft-c. About 3% of the total daily emergence occurred between 8:00 PM and dawn.

At Weslaco, Tex., infrared aerial photography is being evaluated as a survey tool for estimating brown soft scale populations. An increase in scale



population was detected by this method, apparently through differences caused by an increase in sooty mold, which is correlated with scale build-up.

Problems in rearing the brown soft scale during the winter months in Texas were encountered when the citron melons used for laboratory rearing did not hold up well in storage. Mexican squash, Cucurbita moschata, the most promising of several substitutes tried, was an effective host one generation after the scale was allowed to adapt from the citron melons.

In laboratory studies of the fecundity of brown soft scale, crawlers were produced approximately 33 days after the scale had attached. The average number of crawlers produced per female per day ranged from 9.8 to 66.3 between the 41st and 55th day. Significant numbers were still being produced at this time.

In India (PL 480 project A7-ENT-26) 4 species of gall midges affecting the inflorescence of mangoes were identified. Dasineura amaramanjarae Grover, Procystiphora mangiferae (Felt), and P. indica n. sp. infest the blossoms. Erosomia indica n. sp. infests the floral buds, axis of the inflorescence, and the newly-formed fruit and is considered the most serious of the four. Bud damage caused by D. amaramanjarae was estimated at 25 to 30% and that of P. mangiferae was estimated at 60 to 70%.

A citrus blossom midge determined as Dasineura sp., discovered on sweet lime in India in 1964 (PL 480 project A7-ENT-35), was also found attacking many other varieties of citrus. From 50 to 77% of the flower buds were infested with a range of 2-43 larvae/bud. Infested buds become distorted and fall. This is the first Dasineura and the 3rd gall midge reported in association with citrus blossoms.

Surveys in India (PL 480 project A7-ENT-47) also indicated the presence of the midge, Udumbaria nainiensis Grover, on figs in northern India but apparently not in the southern portion. During October-November, the eggs are deposited in the cavity of the young fruit and the larvae consume the floral inflorescence, resulting in aborted non-edible fruits.

2. Subtropical Fruit Flies. Studies in Mexico City revealed that the eye color of Mexican fruit fly pupae during pupal development is a reliable indicator for age. At 80° F the eyes were white up to the 7th day, yellow from the 8th to 9th day, light brown to red brown from the 10th to the 12th day, and iridescent from the 13th to the 15th day. In order to avoid excess radiation damage to emerging adults, Mexican fruit fly pupae should be exposed to gamma radiation 3 days before emergence or when the eyes are in the red-brown color stage.

An attempt is being made in Mexico City to establish laboratory colonies of 3 species of Anastrepha other than A. ludens, the Mexican fruit fly. The purpose is to broaden the scope of olfactometer studies. Candidate materials not attractive to A. ludens may be attractive to other species. Rearing

techniques similar to A. ludens have been developed for A. serpentina. Egg production for A. mombinpraeoptans and A. striata has not been satisfactory and will need further research.

In Mexico City an impure lot of hydrochloric acid severely curtailed the laboratory production of adults of the Mexican fruit fly for 3 months. Larvae produced from medium prepared with this acid were apparently normal in size, vigor, color, and percent entering medium from eggs, but mortality occurred shortly after pupation, resulting in only 1 to 3% adult emergence. The exact mode of action of the impurity could not be determined.

In Hawaii progress was made on the improvement of fruit fly larval diets during the production of 180 million eggs and 109 million pupae. The flies were used largely to support sterile fly release programs and other research. A significant new development was the discovery that Gelgard (a fire-fighting polymer) could be used to control moisture and physical structure of a wheat middlings-shorts-sugar medium that not only replaces the high-cost carrot powder but permits greater production per unit of lateral space as well as depth of medium. The medium also includes torula yeast, a discovery of the Mexico City laboratory, HCL, Nipagen, sodium benzoate, and water. In tests involving several million eggs and multiple generations of fruit flies, dependable production of the Medfly and the oriental fruit fly was possible at a material cost of less than \$16 per million, compared with \$30 per million one year ago. Further research on modifications for melon fly production promise to make possible savings of at least \$25 per million for this species.

Diets of sugar and/or protein hydrolysate exposed to 500 kr gamma radiation had no adverse effect on behavior, survival, fecundity, fertility or reproduction by 3 species of fruit flies. Larval development, as well as the F<sub>1</sub> generation adults, also showed no adverse effects.

Attempts in Hawaii to utilize the oriental fruit fly and melon fly throughout the normal working day for research on sex behavior led to the discovery that the time of mating was determined not only by a diminishing light intensity but also by either a predetermined rhythm or a minimum period of daylight exposure. Flies reared in a reversed diurnal rhythm mated readily under diminishing light in the morning hours after removal from their artificial environment.

In studies at Miami, Fla., basic techniques were developed for mass rearing the fruit fly, Anastrepha suspensa. The Mexican fruit fly larval medium proved to be acceptable, whereas the medium used in the Hawaii Fruit Fly Laboratory was too moist. Cheesecloth-paraffin oviposition shells were accepted by the flies for oviposition.

3. Guava Weevil. Life history studies with the guava weevil (Conotrechetus dimedius) in Mexico City revealed that a diapause takes place in full grown larvae in the soil for 4 or 5 months. Pupation occurs about 1 month



before transformation to adult. The larval diapause enables the weevil to bridge the host free period which occurs between November and May.

## B. Insecticidal and Cultural Control

1. Citrus Insects and Mites. At Riverside, Calif., Temik applied as a 10% granular formulation to the soil surface at the base of citrus trees provided long residual systemic activity. Application of 1.2 g active ingredient per ft<sup>2</sup> gave effective control of the citrus red mite for at least 61 weeks after treatment on potted orange trees. Similar applications to 2-year-old navel orange trees in the field provided effective mite control for 44 weeks and controlled citrus thrips and spirea aphid for 10 and 29 weeks, respectively.

Aerial applications of methyl parathion, malathion (technical and dilute), azinphosmethyl (concentrated and dilute), and carbaryl at dosages designed to suppress but not completely control brown soft scale were applied to a heavily infested citrus grove (240 acres) in Hargill, Tex., to determine the effects on the scale and parasite populations. Methyl parathion caused a pronounced increase in scale population, whereas the other materials had a suppressive effect. Parasites continued to appear in the groves as long as significant numbers of scale were present, despite the repeated use of the pesticides.

Brown soft scale on potted citrus trees in Texas showed a 78% decline 2 weeks after the application of 4 g of 10% Temik granules on the soil. Between 8 and 15 weeks after treatment, control was 100%, after which scales started to reappear in small numbers. Seventeen weeks after application, all treatments were significantly below pretreatment infestation levels while the check had increased by 86-fold. A plant receiving 3 g of Temik was free of scale from the 11th to 13th weeks, while a dosage of 2 g failed to eliminate the scale but suppressed it from the 4th to 13th weeks.

At Orlando, Fla., 51 chemicals were screened for effectiveness against citrus rust mite. Of these, 7 gave at least 95% kill when tested as low as 1 ppm, and 9 additional materials were effective at 2 ppm.

## C. Insecticide Residue Determinations

1. Citrus Insects and Mites. Drift studies at Weslaco, Tex., involving aerial applications of methyl parathion continued to show heavy deposits up to 400 feet from the flight line and in one test heavy deposits were recorded at 800 feet. The latter occurred when the wind direction was directly at right angles to the flight line and the horizontal and vertical wind speeds were lower than in 3 other tests. Filter paper samples gave a clearer picture of the drift patterns than citrus leaves. Prespray levels of methyl parathion and DDT were high on the leaves, apparently the result of drift from cotton and other sprays or build-up from previous drift tests. In bioassay tests, almost complete kills of the parasite, Coccophagus lycimnia, were obtained 400 feet from the flight line and there were few survivors at

800 feet. The coccinellid, Hippodamia convergens, proved highly susceptible to methyl parathion drift, indicating that predator populations could be severely decimated by exposure to drift from this insecticide.

Aerial sprays involving malathion, low volume technical and dilute, demonstrated great variation in drift, depending on weather conditions and mechanical factors. Early tests had indicated that dilute formulations drifted to a much greater extent than the technical. Later observations showed a complete reversal in some cases and other instances where the materials drifted approximately the same distance. Since the equipment and dosages were approximately the same, indications are that temperature, humidity, wind direction, wind velocity, and turbulence have a profound influence on the distance the spray materials may drift.

2. Other Insects. In studies at Hoboken, N.J., methyl bromide remained at relatively high concentrations in the centers of large bags of some seeds for long periods during the aeration period following fumigation. Concentrations of up to 7.5 oz/1000 ft<sup>3</sup> (15.6% of the original 48-oz dosage) were found after 20 hours in a 110-pound bag of Pinus mugo seeds. Some other conifer seeds had concentrations of near 2 oz/1000 ft<sup>3</sup>. Bags of most other seeds contained only a few ppm.

3. Analytical Equipment. At Hoboken, N.J., further tests on chemical gas detector tubes to determine whether hazardous gas concentrations are present in working areas confirmed the usefulness of the Kitagawa tubes for detection of methyl bromide and ethylene oxide at or below concentrations harmful to personnel. However, they were not satisfactory for detection of hydrogen cyanide at low concentrations. In preliminary tests, the Draeger tubes for detection of hydrogen cyanide appeared useful at concentrations that would be hazardous to personnel.

#### D. Biological Control.

1. Citrus Insects and Mites. When the parasites, Encyrtus lecaniorum and Metaphycus stanleyi, were introduced into caged citrus trees infested with brown soft scale at Weslaco, Tex., E. lecaniorum was maintained for at least 9 months, while populations of M. stanleyi diminished after 3 months. E. lecaniorum suppressed but never eliminated the scale populations during this period. The cage was removed from the tree in late spring in order to release the remaining E. lecaniorum in an effort to establish this parasite in the field. Earlier attempts at establishment by adult releases had proved unsuccessful.

Coccophagus lycimnia continued the most abundant parasite of the brown soft scale found in the Rio Grande Valley, constituting in excess of 90% of the parasites collected. Microterys flavus was the second most abundant parasite species. Parasite population trends were similar to the previous year, although lower in number. No parasites were found in the 20 survey groves from June to August, a period of high insecticide usage, and the highest number of parasitized scale was recorded in December.



The interrelationship between pH and salt concentration of virus suspensions appeared to influence deactivation of the noninclusion virus of the citrus red mite in studies conducted at Riverside, Calif. When mite colonies on lemons were sprayed with virus suspension prepared with a buffer of unknown salt composition and molarity at pH values ranging from 3.0 to 12.0, infections were obtained within pH values of 5.0 to 7.0. Additional tests using phosphate buffers at 0.067 M and 0.033 M concentrations demonstrated that the virus was infective between a pH range of 5.35 to 7.38 with the higher concentration of salt and between pH values of 5.0 to 8.1 with the lower salt concentration.

In cooperation with the Department of Biological Control, University of California, 3 species of predatory mites--Amblyseius hibisci Chant, A. limonicus Garman and McGregor, and Typhlodromus occidentalis Nesbitt--when fed a sole diet of citrus red mites infected with a noninclusion virus, lived as long and deposited as many eggs as those fed normal citrus red mites, indicating no detrimental effects of the virus on the predatory mites.

In cooperation with Rincon Insectary, leaf samples collected from 51 citrus groves in central and southern California and sent to Riverside, Calif., for correlation of mite infestation level with incidence of the citrus red mite virus showed that infected mites were present in 27 of the groves, in 8 counties, and on all varieties of citrus represented. High incidence of disease was associated primarily with high population density but was also present in low populations. Epizootics had occurred previously in most of the low population groves.

A natural epizootic of the citrus red mite virus found during January 1965 in a 12.5-acre grove near Riverside, Calif., was surveyed at weekly intervals for 1 year and bi-weekly intervals for an additional 6 months to correlate mite population trends with presence of the disease. An infestation averaging approximately 40 mites per leaf was reduced by the epizootic during a 4-month period, after which the populations fluctuated between 1 to 8 motile forms per leaf, except for 2 minor peaks averaging 10 mites per leaf. A scabicide applied in the fall of 1965 to all except the 15 trees being sampled may have depressed the virus disease by isolating the 15 trees from free migration of mites between trees. Diseased mites were collected in all but 4 of the 63 surveys. Those negative for the disease occurred within the 3-month period following application of the scabicide.

The number of leaves on a mature Hamlin orange tree were counted at Orlando, Fla., in studies to establish models as a means of estimating total populations of insects and mites on citrus. The tree, 18'11" high, with a skirt width of 17'6" and with moderately dense foliage, contained 140,527 leaves. Of these, 111,658 were of the current year's spring flush of growth and 28,869 were of earlier growth flushes. The average area per leaf of the spring flush leaves was 5.8 in<sup>2</sup>; that of the older flush leaves was 9.3 in<sup>2</sup>

2. Subtropical Fruit Flies. A bacterial pathogen of the Mexican fruit fly discovered during the course of chemosterilant screening was determined to be Serratia marcescens Bizio. This is the first time that this microorganism has been recorded as being a pathogen of A. ludens.

An entomogenous fungus in the order Laboulbeniales was found in fairly large numbers on adult Mexican fruit flies in a mango grove in Santa Catarina, Morelos, Mexico, during February and March 1966. Four percent of around 4,500 flies examined were attacked and of these nearly 99% were males. The fungus was found on all parts of the insect including head, antennae, thorax, abdomen, legs, and wings.

#### E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Citrus Insects and Mites. Extracts of California red scale female sex pheromone prepared by various procedures at Riverside, Calif., differed in their relative attractiveness to males. A diethyl ether extract of the condensate of cold-finger-trapped air passed over virgin females appeared the most attractive of 7 different preparations. An ascending thin layer chromatogram of this extract developed with n-hexane-diethyl ether-ethanol produced a major spot with an  $R_f$  of 0.9 and elicited male copulatory response. Fifty  $\mu$ l of this extract placed on dummy females of paraffin drops confined in Munger cells on lemons and compared with 1, 10, and 100 similarly confined virgin females exposed to males in free flight attracted approximately the same numbers of males as the 10 live females, indicating that 1  $\mu$ l of the extract had 0.2 female equivalents of attractiveness.

Males of the California red scale were sterilized by permitting young adults to contact tepa residue on glass surface for 15 to 30 minutes. Twenty to 40% of the females mated to males contacting 0.25 to 0.75% residue produced crawlers, whereas reproduction of untreated females was 98 to 100%. There was evidence that when females were mated with males contacting substerilizing dosages of tepa, there was an increase in male to female ratios in the  $F_1$  and  $F_2$  generations.

In studies at Weslaco, Tex., irradiation of third stage brown soft scale on Mexican squash was explored as a means of releasing pre-emergent parasites in citrus groves without adding to the biotic potential of the natural scale population. When exposed to 5,000 and 10,000 roentgens of gamma radiation, the scales produced limited numbers of crawlers beginning on the 43rd and 44th days, respectively. At dosages of 20,000 and 40,000 r, no crawlers were produced. Untreated scales began normal reproduction on the 42nd day. The crawlers produced at the 2 lower dosages were weak and showed a more pronounced pink coloration than that found in crawlers from unirradiated scale.

2. Subtropical Fruit Flies. In studies at Miami, Fla., to establish an effective radiation dosage for sterilization of Anastrepha suspensa, the reproductive systems of males showed severe damage with no recovery at



dosages of 2,000 r of gamma radiation. No eggs were laid by females that had received 3,000 r or above. The maximum dosage tried, 18,000 r, caused severe damage and heavy mortality to the flies.

With mass rearing methods now available, this information on sterilization dosages establishes a basis for use of sterile male releases for control or eradication of this fruit fly. In lure tests conducted with field populations of A. suspensa, candidate lures were applied to the surface of sticky board traps. Lures that were promising were ENT numbers 26,660X, 26,663X, 28,461, 44,462X, 44,620, 44,624, and 50,022a. Cottonseed hydrolysate and casein hydrolysate were used as standards.

In Mexico tests were conducted to determine if intensive trapping with glass traps baited with cottonseed-hydrolysate-borax would reduce Mexican fruit fly populations and prevent infestations in orange and mango crops. One test in 87 mango trees with 1 trap per tree reduced the population by 60.2% and decreased the larvae per pound of fruit from 23.4 to 3.3. With 3 traps per tree in a semi-isolated mango grove of 212 trees, Mexican fruit fly infestations were reduced from 40 to less than 1 larva per pound. Intensive trapping in a navel orange grove of 2,000 trees with 1,000 traps in Xalapa, Veracruz, Mexico, reduced the on-tree fruit infestation about 50%, as compared to infestation in adjoining section of the grove separated by 8 rows of trees.

In Hawaii a new 30,000 curie irradiator that permits a dose rate of about 5 kr/min has caused irreversible sterility in Medflies irradiated with 5 kr, whereas 9 kr was required in the old USDA-416 curie equipment. The old treatment involved 5 minutes holding of the pupae in cannisters and 10-15 minutes exposure period which may have induced anoxia. Sixteen thousand flies exposed as 7- to 8-day-old pupae for 1 minute to 5 kr immediately after packaging deposited only 4 eggs, all of which were non-viable. A similar lot held for 15 minutes after packaging before irradiation produced 2,700 eggs, of which 3.4% hatched. Metabolic heat raised the temperature in the package from 78 to 82° F. A 9 kr dosage is still required for the melon fly and oriental fruit fly in the 30,000 curie unit to prevent egg deposition and insure irreversible sterility. The larger size of these species (30,000-35,000 pupae per liter vs. 55,000 for Medfly) apparently insured retention of enough air among the pupae to avoid any anoxia during the 15-20 minutes they have been held in the cannister.

The Hawaii station supplied the Guam Department of Agriculture with 8 million sterile oriental fruit flies between July 2 and August 7, 1965. These were released to suppress a well-defined outbreak of this fruit fly. Eradication was again accomplished and no wild flies have been taken on Guam in the last 11 months (33,000 trap days prior to July 1). The male annihilation program (air distribution of methyl eugenol + naled on canec squares) had previously eradicated the species from Saipan, Tinian, Aguijan, and Rota.

In Hawaii a Stickem-coated trimedlure-baited Medfly trap was 50 to 100% more effective than the standard Steiner trap when traps were 50 to 100 feet apart but was 35 to 65% less effective when each trap was given 2 or more acres to draw from. Medflies, attracted by trimedlure and other male Medfly lures, accumulate in the vicinity of the trap and enter slowly. This behavior is believed to give sticky traps an advantage by earlier interception of flies as they move about prior to their final approach. Stickyboards may therefore catch some of the flies brought to their vicinity by competing traps.

In Hawaii maximum concentrate protein hydrolysate-technical malathion bait spray has given promising results for the suppression of 3 species of adult tropical fruit flies. The new formula uses no water other than the 50% moisture in the PIB-7 protein hydrolysate and at the usual 1:4 technical malathion-PIB-7 ratio can be quickly pumped to a molasses-like consistency that will not separate with low agitation nor lose significant amounts of moisture from falling droplets. The conventional bait sprays, because of moisture loss, must be applied from low altitude and under moderate temperatures to avoid droplet shrinkage and excessive drift. The maximum concentrate formula was applied from elevations of up to 400 feet in the 100-foot swaths as much as 200 feet apart, which reduced flying 80%, increased the safety over rugged terrain, permitted work in windy weather, and reduced spray load per square mile by 70%. The technical malathion bait spray was as effective as full coverage low-volume technical malathion sprays without the protein hydrolysate at one half the rate of toxicant per square mile.

The new malathion-PIB-7 formulation was used by pest control agencies to eradicate a new incipient Medfly infestation discovered in Brownsville, Tex., in 1966, with preliminary indications of complete success.

Studies in Hawaii showed that formulations of cue-lure, methyl eugenol, and trimedlure with toxicant could be dropped separately or as a combined mix for simultaneous eradication of the 3 species of tropical fruit flies by the male annihilation method. In standard tray tests there were no significant differences in the kill of oriental, melon, or Mediterranean fruit flies when the 3 lures were applied as a single foliage application with naled as the toxicant and Myverol as the thickener as compared to interspersed discrete droplets of each of the 3 separate lure formulations.

In Hawaii tests continued with a new thickener for foliar applications of grease-like deposits of male lures with toxicants. In tests with trimedlure, medlure, methyl eugenol, and cue-lure, CAB-O-SIL (a pyrogenic silica of very small particle size) at 7 to 12% produced thixotropic mixtures of consistencies comparable to those obtained with Myverol. CAB-O-SIL can be mixed quickly when cold. Compared with Myverol, this thickener leaves a drier deposit that tends to flake off. Both CAB-O-SIL and Myverol deposits of cue-lure-naled on thick foliage remained effective for periods of more than 2 months.



Aerial applications of cue-lure-naled formulations with the extender (Myverol) were tested in Hawaii against melon fly populations. Each test involved about 5 mi<sup>2</sup> with applications at 4 to 6 week intervals of cue-lure plus 5% naled, plus 8 to 12.5% Myverol at rates of 5 to 6 lb/mi<sup>2</sup>. The liquid formulation was discharged from the aircraft in discrete ejections of a few milliliters at a time by means of a hand operated grease pump. Various combinations of dosage, percent Myverol, swath width, and altitude were tried. The male catches of 99% below the immediate pretreatment value was obtained with 6.4 lb/mi<sup>2</sup> of a formulation containing 12% Myverol applied in flight lines 600 feet apart from 500 feet above the ground. Wider spacing of the flight lines or distance between ejections, lower dosage, or more fluid formulas with less Myverol gave less satisfactory results. A similar test of 2 applications of 83% cue-lure, 5% naled, and 12% (by wgt) CAB-O-SIL (EH-5) at the rate of 6.7 lb/mi<sup>2</sup> was conducted in the same area several months later. Applications were made at 4 week intervals in swaths 500 feet apart from 700 feet elevation. Pretreatment catches of male flies in cue-lure traps within the area averaged 120 per trap day. Male catches were reduced 99.3% within 24 hours, 99.9% in 5 days, and were still 99.0% less at the second application, which reduced the catch another 95%. The treated area contained a 14x larger population at the time of the first treatment than the control areas on similar slopes north and south of the plot. The population in the controls 39 days later was unchanged. Evidence was obtained that these applications caused a rapid and substantial male melon fly population reduction up to  $\frac{1}{2}$  mile downwind. Immigrating fertile females prevented any infestation reduction in host fruit. The female/male ratio of 1.1 to 1 in liquid bait catches before the first application changed to 20:1 within 3 weeks. In the control areas female/male ratios remained unchanged. Of 262 females caught in liquid baits when the ratio was 20:1, 58% were gravid and 69% of these had mated. Of non-gravid females, 12% had mated. Of all females, 55% had not mated. This method and formula appears sufficiently developed for large-scale use against isolated populations. The cost for materials and application would be about \$75 per square mile per application.

In Hawaii large-area tests of 2 applications of 85% medlure, 5% naled, and 10% Myverol (percent by wt) were applied on an area of moderate Mediterranean fruit fly population. The first application on 4.8 mi<sup>2</sup> at the rate of 5.3 pounds of mixture per square mile in flight lines 1,000 feet apart reduced the male population by only 64%. The second application at the rate of 9.28 pounds of mixture per square mile from flight lines 500 feet apart produced a maximum reduction of 73%. Plans for additional Medfly tests on isolated populations of the Medfly in the Azore Islands are being developed.

In Hawaii fruit fly bait sprays of protein hydrolysate-technical or wettable powder malathion caused permanent damage to auto finishes of all types used on new or recent models when droplets were applied to panels heated by full sunlight and allowed to remain several hours. However, droplets from aerial sprays under cool conditions marked acrylic and nitrocellulose lacquers and acrylic enamel but not alkyd enamel after 20 hours' exposure. Droplets washed off with a mild cleaner after  $\frac{1}{2}$  hour caused only light stains on the

most susceptible finishes. Acrylic enamel and lacquer were permanently marked after exposures of only one hour. Droplets of a mixture of 2 pounds Zectran 25% wettable powder plus 1 quart PIB-7 per gallon of spray left only light, easily removable stains on all finishes, including acrylic lacquers and enamels after 4 hours' exposure in sunlight. The Zectran formulation is the least injurious to auto finishes of any effective substitute found to date for malathion in protein hydrolysate bait sprays.

3. Southern Green Stink Bug. In Hawaii, when 5th instar nymphs of the southern green stink bug were subjected to gamma radiation dosages of 2, 3, 4, 5, 8, or 12 kr, only the females treated with the two lower dosages deposited eggs but none hatched. A proportionate increase in nymphal and adult mortality resulted with increase in dosage. In another test females irradiated with 3 kr were paired with normal males. Of 26 pairs used initially, a total of 833 eggs were obtained with 0.9% hatching. Normal females paired with irradiated males at the same dosage deposited 1,631 eggs of which 4.9% hatched from 13 pairs. Twenty-six pairs in the control produced 3,207 eggs, of which 46.6% hatched.

#### G. Insect Control Treatments for Commodities Regulated by Plant Quarantine

1. Subtropical Fruit Flies. In Hawaii the use of modified atmospheres of low oxygen levels to protect fresh fruits during treatment with gamma radiation requires an increase of the minimum disinfestation dose. Fricke dosimeters saturated with atmospheres containing 0.01 to 1.0% oxygen showed that the expected dose was halved. The expected dose was halved by 100% carbon dioxide or 99.9% nitrogen.

In Hawaii the minimum disinfestation dose for fumigation of papayas wrapped in tissue and packaged in ventilated orange cartons at 50° or 60° F with ethylene dibromide was 24 oz/1000 ft<sup>3</sup> for 2 hours when the fruits were refrigerated at 42<sup>±</sup>2° F for 1 to 3 days after 3 hours of aeration at 60° F. The total insect population tested was more than 126,000. No survivors were obtained when the fumigated fruits were aerated at 60° F for 24 hours and then refrigerated. No survivors were obtained when the fumigated fruits were refrigerated at 49<sup>±</sup>1° F after the 3- or 24-hour aeration periods.

The appearance, flavor, and aroma of Euphoria longan (Lour.) Steud was not significantly altered by fumigation with ethylene dibromide at the dose of 8 oz/1000 ft<sup>3</sup> for 2 hours at 70° F when the treatment was followed by storage at room temperatures of 66-88° F or at 45° F.

Cold storage at 45° F before and after treatment at 45° F did not affect the mortality of the Mediterranean, melon, and oriental fruit flies in papayas packaged and irradiated in modified papaya cartons at the dose of 21 kr. Refrigeration reduced the pupation of moribund larvae with time.

Chinese peas required continuous refrigeration at 35° F to tolerate irradiation up to 50 kr.



2. Mango Weevil. In Hawaii the minimum disinfestation dose for adult mango weevils was 25 kr of gamma radiation. At this dosage all larval stages were killed and pupae and adults were effectively sterilized.

Standard vapor heat treatments were ineffective against adult mango weevils in the seeds of mangoes. One-hour ethylene dibromide dip treatments at 120°F appeared to be effective but resulted in a serious residue problem.

3. Other Insects. At Hoboken, N.J., the methyl bromide-resistant Cecidomyid, Plemeliella abietina, and a seed chalcid, Megastigmus sp., found infesting spruce seeds imported from Europe were effectively controlled in small-scale, 24-hr atmospheric fumigations at near 72° F by carbon tetrachloride-carbon disulphide 80-20 mixture (by volume) at a rate equivalent to 4 and 6 lb/1000 ft<sup>3</sup> of the carbon disulphide (20 and 30 lb of the carbon tetrachloride). Preliminary tests indicated good tolerance to this fumigant at these schedules by Pinus nigra seeds.

In further tests of various wrappings or packaging materials in New Jersey, aluminum foil and Styrofoam, occasionally used with imported plants or commodities, were highly impervious to methyl bromide. Only 3.3% and 27.1%, respectively, of the chamber concentration permeated through the samples in 8 hours. These materials require removal, opening or perforations prior to fumigation to insure effective treatment. A manila envelope used for seeds with a permeability of 67.1% in 1 hour was recommended for corrective action for use during 2.5-hr fumigations pending further study.

In preliminary tests in New Jersey at temperatures near 91-93° F, atmospheric fumigation with 3 lb/1000 ft<sup>3</sup> of methyl bromide for 2.5 hr was found to be the minimum effective schedule for Bruchus rufimanus adults in faba beans from the Mediterranean area. Occasional survival of these or other bruchids in various host seeds has occurred with 3 lb for 2 hr or 2.5 lb for 2.5 hr at these temperatures.

In small-scale tests there was little or no difference in resistance to fumigation with methyl bromide or ethylene oxide-carbon dioxide 10-90 mixture between lots of the snail, Theba pisana, received from Italy in April, May, or August 1965. There was an apparent increase in resistance as the temperature of the fumigation was lowered from near 50° to near 40° F and the effect was more pronounced at lower temperatures.

## I. Insect Vectors of Diseases

1. Citrus Insects and Mites. In vector studies at Orlando, Fla., to determine the possibility of multiple transmission of tristeza virus by melon aphids transferred to a succession of indicator plants, 3 transmissions appeared among plants of the second series, indicating need for more study. In tests of 200, 400, or 800 melon aphids per indicator plant, the number of transmissions increased with the aphid population per plant, but additional trials will be required before definite conclusions are drawn. There was

also evidence that the rate of aphid transmission of tristeza virus decreased as new growth matured, from the third week and thereafter. In preliminary tests of whiteflies as possible vectors of tristeza virus, 1 indicator plant in 20 trials showed vein-clearing symptoms typical of this virus, the first suggested implication of whiteflies as vectors of this disease.

#### PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

##### Basic Biology, Physiology, and Nutrition

Benschoter, C. A., and R. Paniagua G. 1966. Reproduction and longevity of Mexican fruit flies, Anastrepha ludens (Diptera: Tephritidae), fed biotin in the diet. Ann. Entomol. Soc. Amer. 59: 298-300.

Grover, P., and S. N. Prasad. 1966. Studies on Indian gall midges XVI. Four species of gall midges (Cecidomyiidae: Diptera) affecting inflorescence of mango. Cecidologia Indica 1 (1): 1-12.

McFadden, M. W. 1966. Discovery of fossils of Hermetia illucens (Linnaeus) in Mexico. Proc. Entomol. Soc. of Wash. 68: 131-32.

Nakagawa, S., and T. Yamada. 1965. Two varieties of Sesbania grandi flora as fruit fly hosts. J. Econ. Entomol. 58: 796.

Tashiro, H. 1966. Improved laboratory techniques for rearing California red scale on lemons. J. Econ. Entomol. 59: 604-8.

##### Insecticide Residue Determinations

Getzendaner, M. E., and H. H. Richardson. 1966. Bromide residues from methyl bromide fumigations of fruit and vegetables subjected to quarantine schedules. J. Agr. Food Chem. 14: 59-62.

##### Biological Control

Gilmore, J. E. 1965. Preliminary field evaluation of a noninclusion virus for control of the citrus red mite. J. Econ. Entomol. 58: 1136-40.

##### Insect Sterility, Attractants, and Other New Approaches to Control

Keiser, I., L. F. Steiner, and H. Kamasaki. 1965. Effects of chemosterilants against the oriental fruit fly, melon fly, and Mediterranean fruit fly. J. Econ. Entomol. 58: 682-85.

McFadden, M. W., and R. E. P. Rubio. 1965. Compounds affecting the reproductive capacity of the Mexican fruit fly. USDA ARS Circ. 33-108.

Sanchez Riviello, M., and J. G. Shaw. 1966. Use of field bait stations in chemosterilant control of the Mexican fruit fly. J. Econ. Entomol. 59: 753-4.



Shaw, J. G., W. P. Patton, M. Sanchez Riviello, and L. M. Spishakoff. 1966. Mexican fruit fly control. Calif. Citro. 209-14.

Steiner, L. F., W. C. Mitchell, E. J. Harris, T. T. Kozuma, and M. S. Fujimoto. 1965. Oriental fruit eradication by male annihilation. J. Econ. Entomol. 58: 961-64.

Insect Control Treatments for Commodities Regulated by Plant Quarantine

Balock, J. W. 1965. Differential effect of gamma radiation on fruit flies and fruit fly parasites. J. Econ. Entomol. 58: 1169.

Balock, J. W., A. K. Burditt, Jr., Stanley T. Seo, and Ernest K. Akamine. 1966. Gamma radiation as a quarantine treatment for Hawaiian fruit flies. J. Econ. Entomol. 59: 202-4.

Richardson, H. H. 1965. Quarantine fumigation of imported commodities with methyl bromide or ethylene oxide mixture under tarpaulin. Proc. XIIth Intern. Cong. of Entomol., London: 654.

Richardson, H. H., and H. Roth. 1965. Methyl bromide, sulfuryl fluoride, and other fumigants against quarantinable Cochlicella and Theba snails. J. Econ. Entomol. 58: 690-93.

Roth, H., and H. H. Richardson. 1965. Tolerance of some imported vegetables to methyl bromide fumigation and hot water treatments. J. Econ. Entomol. 58: 1086-89.

Steiner, L. F. 1966. Gamma irradiation for disinfestation of export fruits and vegetables. Hawaii Farm Sci. January. 15(1): 11-12.

PUBLICATIONS - STATE EXPERIMENT STATIONS

Dean, H. A. 1965. An Aphytis complex (Hymenoptera: Eulophidae) of chaff scale. Ann. Entomol. Soc. Amer. 58: 142-5. (Tex.)

Elmer, H. S. 1965. Banks grass mite, Oligonychus pratensis Banks, on dates in California. J. Econ. Entomol. 58: 531-4. (Calif.)

Elmer, H. S. 1965. The Yuma spider mite, Eotetranychus yumensis on citrus. J. Econ. Entomol. 58: 534-36. (Calif.)

Jeppson, L. R., M. J. Jesser, and J. O. Complin. 1965. Response of susceptible strains of the Pacific spider mite and the citrus red mite to O-isopropyl O-(2,4,5-Trichlorophenyl) phosphoramidate and phosphoramidothioate. J. Econ. Entomol. 58: 466-67. (Calif.)

Mitchell, W. C., R. M. Warner, and E. T. Fukunaga. 1965. Southern green stink bug, Nezara viridula (L.), injury to macadamia nut. Proc. Hawaii Entomol. Soc. 19: 103-9. (Hawaii)

ORNAMENTAL SHRUB, FLOWER, AND TURF INSECTS

Entomology Research Division, ARS

Problem. Ornamental shrubs, flowers, and turf are damaged by the feeding of a variety of insects and mites and by diseases spread by insects. Effective and safer control measures are needed for many of these pests. Knowledge of the distribution of insect pests of these plants and information on their biology and behavior are required to provide a sound basis for the development of practical, effective, and safe control measures. Insecticidal and cultural methods of control that will not affect adversely the growing plants or natural enemies of the pests or result in objectionable insecticidal residues are needed. The nature and cause of strains of insects and mites resistant to insecticides and means of overcoming or preventing resistance require continuing investigation. The role and use of biological control agents should be more fully explored and efforts made to integrate biological, insecticidal, and cultural control methods. Use of controlled light and other physical factors as possible means of controlling greenhouse pests should be given more attention. Increased emphasis should be placed on attractants, chemosterilants, and growth or reproduction-affecting substances.

USDA AND COOPERATIVE PROGRAM

The Department has a long-range program of basic and applied research on insect and mite pests of ornamental shrubs and flowers at Beltsville, Md., Farmingdale, N.Y., and Sumner, Wash., in cooperation with State Experiment Stations of Maryland, New York, Oregon, and Washington, and with the Crops Research Division; and on turf insects at Moorestown, N.J., and Geneva, N.Y., in cooperation with the State Experiment Stations of New Jersey, New York, and Michigan, and the Northern Utilization Research and Development, Plant Pest Control, and Agricultural Engineering Research Divisions of ARS. Research on turf insects is also conducted under grant with the University of Florida.

The Federal scientific effort devoted to research in this area totals 8.3 scientist man-years. Of this 1.0 man-years are devoted to basic biology and nutrition; 2.6 to insecticidal control; 0.6 to insecticide residue determination; 1.1 to biological control; 2.2 to insect sterility, attractants, and other new approaches to control; 0.1 to evaluation of equipment for insect detection and control; 0.1 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases; and 0.5 to program leadership.

In addition Federal support of research in this area under grant provides for 0.4 professional man-year devoted to basic biology and 0.2 to insect attractants.

A PL 480 grant to Poland provides for studies on susceptibility of red spider mites to acaricides and on the cholinesterase in red spiders as influenced by acaricides.



## PROGRAM OF STATE EXPERIMENT STATIONS

The State stations are devoting 17.7 scientist man-years to the research in this area.

### PROGRESS--USDA AND COOPERATIVE PROGRAMS

#### A. Basic Biology, Physiology, and Nutrition

1. Japanese Beetle. A diet was developed for feeding adult Japanese beetles at Moorestown, N.J. Laboratory reared females fed this diet laid an average of 16 eggs per female as compared to 2 eggs per female fed apple slices.

Results of studies on developmental time of various immature stages of Japanese beetle showed that approximately 7.8, 12.2, and 6.9 days were required respectively for prepupal, pupal, and adult pre-emergence periods at 77° F as compared to 4.7, 7.5, and 4.4 days in each case at 84.2° F.

Also at Moorestown, N.J., a number of commercial lacquers, paints, and fluorescent materials were evaluated for use in marking Japanese beetle adults for use in sterile insect release and migration studies. A V & S Gloss Spray Enamel #1342, canary yellow, was found to be the most satisfactory of marking materials tested. There was no apparent toxicity to the beetles.

Fifty male, marked Japanese beetles were placed with 25 female beetles for sexual response to the female. Forty-six extruded their aedeagus within 90 minutes. The following day the 50 marked beetles were released in a constant temperature-humidity room held at 86° F and 75% relative humidity. Forty-seven flew within 20 minutes.

2. Cuban May Beetle. Surveys conducted in 1965 at Miami by the University of Florida under a grant showed that 210 square miles were infested with Cuban May beetle in Dade County as compared to 10 square miles in 1959. Cuban May beetle adults were noted to feed on numerous shrubs and trees, especially Trema sp., West Indies mahogany, royal poinciana, shaving brush tree (Pachira sp.), sapodilla, roseapple, and Philodendron, resulting in severe defoliation.

Larval surveys revealed that the heaviest infestations were in St. Augustine grass, with as many as 16 larvae per square foot. In waste areas under Trema sp., as many as 25 larvae per square foot were found. Most larvae occurred in the top 3" of soil. There has been no evidence of injury to plants from larvae feeding.

Mating of the Cuban May beetle occurs immediately after flight begins in the evening and usually lasts 15 to 20 minutes, although a few were observed to continue as long as 40 minutes. The adults fly to food plants or move to higher foliage in the trees after mating at dusk. They feed throughout the

night and do not leave until dawn. Beetles do not drop to the ground as previously believed but take flight and appear to fly toward dark, bushy areas.

Attempts to rear larvae of the Cuban May beetle in hollow drain tiles sunk into the ground were unsuccessful. The beetles oviposited in the soil and eggs hatched but no larvae developed. Artificial diets attempted have not been successful except one larva survived 6 weeks on Shorey's diet.

Adult Cuban May beetles marked with fluorescent paints lived as long as unmarked beetles. Applications of clear lacquer over the paint caused 50% mortality within 24 hours. Released marked beetles were recaptured up to 1300 feet from point of release. A few marked beetles were more than 1 month old when recaptured.

3. Two-spotted Spider Mite. In Poland (PL 480 project E21-ENT-5) efforts were made to develop a highly resistant strain of Tetranychus urticae by repeated selection pressure with malathion on 8 colonies of mites from various locations. However, resistance was not increased beyond 2.5-fold levels. A mite collection from greenhouse roses where acaricides had been applied gave similar negative results. These findings agree with those of studies in the United States where resistance appeared in only a few greenhouses of the thousands being treated intensively with the newer insecticides.

#### B. Insecticidal and Cultural Control

1. Japanese Beetle Grubs. Soil in field plots in pasture located near Sparta, N.C., were treated with different dosages of diazinon and carbaryl in July 1965. Adults had laid eggs but were still active and some had hatched to first-instar larvae. Late third-instar grubs from 1964 that had not yet transformed to pupae were also present. In September 1965, the reductions in grub population in the diazinon plots were about 38, 89, and 97% at 1.6, 4, and 6.7 lb/acre respectively, and 85 and 91% in the carbaryl plots at 9 and 18 lb/acre respectively. Populations in untreated plots averaged 15 larvae per square foot.

2. Two-spotted Spider Mite. At Farmingdale, N.Y., Temik on corn cob granules applied to the soil surface in greenhouse rose beds at 12 pounds actual toxicant per acre killed two-spotted spider mites. After 5 weeks no living mites were found on treated plants, but heavy populations had built up on untreated plants. Retention of toxicity in new rose foliage for at least 35 days was shown by transfer of mites to treated plants and resulting mortalities of 48% on young expanding leaves and 97% on older leaves.

At Beltsville, Md., 7 weekly applications of oxydemetonmethyl in sprays or dichlorvos in aerosol caused no injury to leaves or bracts of latex-free poinsettias and reduced resistant mites to noninjurious levels. Diazinon and dimethoate caused no foliage injury, but diazinon caused fading of red color in bracts. Dimethoate caused marginal necrosis as well as bract fading. Binapacryl was again superior for control of resistant two-spotted



spider mites and caused no visible leaf injury but caused slight fading of bracts. Two or three binapacryl sprays before bract development would be acceptable. Malathion WP or EC at low dosages caused no injury to foliage or bracts, but at higher dosages bract damage was severe.

3. Pritchard Mealybug. Soil drenches containing diazinon, malathion, and zectran controlled Pritchard mealybugs on African violets at Beltsville, Md.

4. Tulip Bulb Aphid. At Sumner, Wash., phorate, disulfoton, and Bay 25141 preplant furrow treatments in September 1964 at the rate of 2 pounds actual/acre gave 100, 99, and 98% control, respectively when bulbs harvested in July 1965, were artificially infested with tulip bulb aphids. In October 1965, tulip bulb aphid mortality after infestation of harvested bulbs was as follows: Phorate-15%, disulfoton-88%, and Bay 25141-22%.

Tulip bulb aphids were controlled in excess of 90 days on dormant iris bulbs dipped for 5 minutes in either benzene hexachloride or endosulfan at a 1-400 dilution. Cygon and oxydemetonmethyl failed to control the aphid at the end of 30 days after a 15-min dormant bulb dip. None of the treatments were phytotoxic or prevented aphids from feeding on the foliage after the bulbs were forced.

On iris bulbs that had broken dormancy and had growing tips of 1 inch in length, a 5-min dip in Cygon and oxydemetonmethyl gave complete aphid control throughout the forcing period. BHC and endosulfan failed to control the aphid after new foliage was produced.

5. Orange Tortrix Larvae. At Sumner, Wash., detached geranium leaves were dipped in either Zectran or Thuricide 90T and placed in petri dishes. Fourth instar orange tortrix larvae placed on the leaves 24 hours later left the Zectran treated leaves in 2 hours or less and all died within 24 hours without any feeding damage. The larvae placed on Thuricide 90T treated leaves did not feed for about 24 hours. At the end of 1 week, only about 30% of the larvae were dead on the Thuricide-treated leaves and larval feeding was extensive. Zectran applied at this rate showed no phytotoxic effect on 15 varieties of rhododendrons, 4 varieties of fuchsias, 7 varieties of azaleas, and on holly, huckleberry, and gloxinias.

6. European Chafer. At Geneva, N.Y., malathion LV (low volume) concentrate at 1.4 oz actual toxicant per medium size tree gave 86.5% control of European chafer adults the first night. At 8.2 oz this material gave 86.9% and 77.2% control 4 and 10 nights, respectively, after application.

Laboratory tests at Geneva, N.Y., showed that the initial effectiveness of aldrin and dieldrin against third instar chafer larvae was suppressed by muck soil and that the degree of suppression diminished with increased exposure.

7. Cuban May Beetle. Under a grant at the University of Florida, Miami, aldrin and heptachlor have shown the greatest reduction in number of adults emerging each season from soil-treated plots as compared to untreated plots.

In preliminary screening tests, 100% mortality was obtained in 24 and 48 hours when Cuban May beetles were exposed to foliage sprayed with diazinon at 0.25 or 0.50 lb/100 gal and in 48 hours when 1 lb/100 gal of malathion, carbaryl, or endosulfan was used. DDT residues did not give satisfactory control.

#### C. Insect Residue Determinations

1. European Chafer. At Geneva, N.Y., drosophila bioassays of soil residues from field plots treated with granular parathion, diazinon, carbaryl, and Bay 39007 at 20 pounds, or phorate and Zytron at 10 pounds per acre disced to a 3" depth indicated that the insecticide treatments were inadequate for seasonal control (12-14 weeks) of first instar European chafers.

Drosophila bioassays also indicated that activated charcoal applied at rates up to 320 times the amount of dieldrin present in field plots failed to render the soil nontoxic.

#### D. Biological Control

1. Japanese Beetle. Milky disease in granular formulations were applied by airplane at the rate of 51 pounds per acre to two 10-acre plots in Lumpkin County, Ga., during September 1965. Formulations applied to one plot contained 100,000 milky disease spore per gram and to the second contained 200,000. Examinations of soil samples in May 1966 provided inconclusive data on effectiveness of the treatment.

Soil samples from field plots near Sparta, N.C., treated in December 1964, with milky disease were collected for bioassay on May 12, 1966. Results showed 24, 76, 48, and 80% diseased larvae in plots treated with 2, 20, 200, and 2,000 pounds per acre respectively, of a granular formulation containing 1,000 spores/g. Percentages of diseased larvae were 24, 52, 56, 80, respectively, where 2, 20, 200, or 2,000 pounds per acre of a dust formulation containing 1,000 spores/g had been applied.

Also, at Moorestown, N.J., a Bacillus sp. has been cultured in the laboratory on several types of media, including brain-heart infusion agar, nutrient agar, and yeast dextrose agar. Exposure of Japanese beetle grubs to these in vitro spores resulted in 75 to 90% infection.

#### E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Japanese Beetle. At Moorestown, N.J., male Japanese beetles were sterilized by short interval contacts with surfaces sprayed with tepa. Female beetles copulate more than once. Females copulating first with sterile



males and then with fertile males deposit fertile eggs. However, if a sterile male mates with a female previously mated with a fertile male, ova are infertile. The mean dosage of tepa needed to sterilize males is .0625%. This dosage only sterilized about 34% of the females. A 1% tepa solution is needed to sterilize 100% of the females.

At Moorestown, N.J., 19 males were treated with 10 ug tepa (a 90% sterilizing dosage) and 19 untreated were kept as controls. Virgin females equal in numbers to the surviving males were placed with males at intervals of 4 to 5 days, removed after copulation, and fertility of the ova determined. No progression toward increased fertility with time extension occurred. Sterility remained at 90% except in the final group of females where sterility dropped and then only 1 of 5 ova was fertile.

At Moorestown, N.J., 31 different aromatics were screened in an all glass, closed-type olfactometer for attractancy to laboratory reared virgin female Japanese beetles starved for 12 hours before exposure. The more promising of these attractants were tetra hydro mugyl acetate, citronellol, citronellyl methyl acetal and fructose.

A large-scale bait trap experiment on Nantucket Island utilizing 2,332 Ellisco Japanese beetle traps baited with anethole-eugenol (9:1) resulted in the capture of 22,691 Japanese beetles, an average of 10 per trap. Traps in low land areas that retained moisture or in irrigated lawn areas averaged 31 and 23 beetles per trap, respectively. Beetles first emerged on the island July 4 and continued their activity through September 30, a period of 89 days. Peak captures occurred August 15 to 31.

In conjunction with this experiment, a number of candidate bait combinations were tested. Phenyl ethyl butyrate-eugenol 9:1, technical geraniol-eugenol 9:1 baits were more effective attractants than the standard anethole-eugenol bait. Caproic acid-eugenol 9:1, caproic acid alone, phenyl ethyl butyrate alone or with caproic acid 9:1 parts, phenyl ethyl butyrate-caproic acid-eugenol, 1:8:1, and a 10% fermenting aqueous solution of dark brown sugar-Tween 20,9:1 were less effective than the standard bait.

Bumblebees were attracted to the Japanese beetle traps during 1965 in large numbers, and 1,823 standard traps caught 18,183 bumblebees during the season and 1,166 were caught in traps with special baits. Most of the bumblebees were workers. White traps were the most attractive to bumblebees, yellow next, and green least attractive. Similar results were obtained in unbaited, colored traps.

Other pollinating insects taken in traps in small numbers included Apis mellifera (Honeybee), Magachille addenda, and Halictus and Lasioglossum sp.

Male and female Japanese beetles responded to cold trap collected sex odors at Moorestown, N.J. Males extended their antennae and assumed a copulatory position. Between 62 and 85% of the males were attracted to the female

extract and moved to it passing up the male extract. Females did not respond to the female extract but extended their antennae, assumed a copulating position, and moved toward the male extract when they were exposed to it.

2. Aphids. At Farmingdale, N.Y., from 96 to 99% aphid repellency was obtained by aluminum foil, smooth or embossed aluminum on wet strength paper, aluminum printed paper 2-inch foil pieces applied to black asphalt to give 80% aluminum coverage, and aluminum dust on asphalt. Titanium white in four mil polyethylene repelled 97% of flying aphids but in tests over soil did not prevent germination and growth of weeds. Aluminized plastic ribbon suspended 1 foot above ground level was not effective.

Yellow water-pan traps, placed on a pole at 3-foot levels from the ground up to 15 feet showed that 72% of the aphids were trapped at ground level and that progressively fewer aphids were trapped at elevations up to 12 feet. On poles over 4-foot and 16-foot squares of aluminum the aphids trapped at ground level were reduced 92 and 98% respectively. A few more aphids were captured at the 3-and 6-foot levels, but at all heights over aluminum the catches were lower than on unmulched check plots.

3. Orange Tortrix. In field cage studies at Sumner, Wash., a trap containing 10 one-day-old virgin female orange tortrix moths caught 82% of the total male population released in the cage at the end of 5 days' time. The greatest single day's catch occurred on the second day when 55% was trapped. The effectiveness of the trap dropped rapidly after the second day.

In laboratory cage tests, traps containing 1, 5, 10, or 25 live one-day-old virgin female orange tortrix moths caught 54%, 72%, 27%, and 28%, respectively, of the male moths released in the cage. Overcrowding of females in the trap apparently causes a loss in the effectiveness of the trap.

4. European Chafer. At Geneva, N.Y., blue-green lamps, infrared radiation, and silhouetted black light were found inferior to conventional black light as lures for European chafer adults. Baiting black light traps with 15 to 50 virgin or non-virgin male or female European chafer adults did not increase attractiveness as compared to non-baited black light traps.

5. Cuban May Beetle. In studies under a grant at the University of Florida, Miami, 50,000 Cuban May beetles were caught in a 30W black light trap in 7 nights. Circular-22W, semi-directional light traps averaged 10,000 beetles per week.

#### F. Evaluation of Equipment for Insect Detection and Control

1. Japanese Beetle. Low volume malathion sprays applied by helicopter at 8 oz/acre on 400 acres in the Tennessee valley killed 90 to 95% of the adult beetles present at the time of application. Eight applications at 5 to 7-day intervals during the period of adult activity suppressed populations



throughout the emergence period. Collections of insects and observations indicated that the sprays killed many beneficial insects in the treated area. Honey bees in unprotected hives were destroyed after 4 applications, but bee-hives protected by a plastic shade remained active.

At Moorestown, N.J., a Japanese beetle shipping container was developed from a 1-gallon ice-cream carton. The container can be taken to the field and collected beetles (approximately 3,000) placed directly into the carton.

Approximately 50,000 beetles were shipped from Georgia and North Carolina during June. Mortality was less than 1%.

#### G. Insect Control Treatments for Commodities Regulated by Plant Quarantine

1. European Chafer. At Geneva, N.Y., methyl bromide fumigation at  $\frac{1}{2}$  pound per 100 square feet applied under plastic film to recently cultivated field plots gave 100% control of third instar European chafer larvae 6 inches below the surface. Air temperature under the film at application was 85° F. Mortalities occurred within 24 hours.

#### H. Varietal Evaluation for Insect Control

At Beltsville, Md., infestations of vegetable leaf miners in 17 varieties of chrysanthemums varied from complete immunity to high susceptibility. Hatching larvae varied from 3 in one variety (Princess Anne) to 139 in another (Blue Chip) when plants of uniform size were exposed to ovipositing adults. Survival of larvae in Princess Anne was 0% and in Indian White it was 94.5%. Development of larvae in resistant varieties of chrysanthemum was slower than in susceptible varieties, 10.8 vs. 9.7 days. The average developmental period for all chrysanthemum varieties was 10.1 days compared to 6.2 days in lima bean.

#### I. Insect Vectors of Diseases

At Farmingdale, N.Y., mulches of 6 reflective test materials varied in their repelling action to alate aphids and in reduction of CMV infection in gladiolus. The mulches in descending order of efficiency were: smooth aluminum on paper, embossed aluminum on paper, white plastic, aluminum powder on asphalt, black plastic, and aluminized plastic. At first the aluminized plastic was equal in repellency to aluminum on paper but lost its repellency as the aluminum loosened from the plastic.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Basic Biology, Physiology, and Nutrition

- Hamilton, D. W. 1965. Life cycle and control of scales. Publicacion Miscelanea No. 23, Instituto Interamericano de Ciencias Agricolas (1<sup>a</sup> Reunion Technica Internacional sobre Plagas y Enfermedades de Los Cafetos) San Jose, Costa Rica: 110-15.
- Hamilton, D. W. 1965. Identification of insects and mites collected in Guatemala and Costa Rica in 1964. Publicacion Miscelanea No. 23. Instituto Interamericano de Ciencias Agricolas (1<sup>a</sup> Reunion Technica Internacional sobre Plagas y Enfermedades de Los Cafetos), San Jose, Costa Rica: 115-17.

Insecticidal and Cultural Control

- Hamilton, D. W. 1966. Injury to trees from insecticide mixtures containing highly concentrated petroleum hydrocarbon solvents or penetrants. Hoosier Kernel XIII: 11-12.
- Hamilton, D. W. 1965. Future research needed for control of insects and mites on coffee. Publicacion Miscelanea No. 23, Instituto Interamericano de Ciencias Agricolas (1<sup>a</sup> Reunion Technica Internacional sobre Plagas y Enfermedades de Los Cafetos), San Jose, Costa Rica: 115-17.
- Jacklin, S. W., and F. F. Smith. 1966. A technique for testing acaricide residues against two-spotted spider mites on field grown roses. J. Econ. Entomol. 59: 244.
- Jacklin, S. W., W. L. Klarman, and F. F. Smith. 1966. A current look at pest and disease control of outdoor roses. Amer. Rose Ann. 51: 68-72.
- Smith, Floyd F., A. L. Boswell, and George S. Langford. 1966. Controlling mealybug infestations on African violet roots. Flor. & Nur. Exchange 146: 14-15.
- Smith, Floyd F., and George V. Johnson. 1966. Pests of ornamentals in home gardens. Handbook of Garden Pests. Plants and Gardens 22: 66-74. Brooklyn Botanic Garden.

Insect Sterility, Attractants, and Other New Approaches to Control

- Ladd, T. L., Jr. 1966. Egg viability and longevity of Japanese beetles treated with tepa, apholate, and metepa. J. Econ. Entomol. 59: 422-25.

Insect Vectors of Diseases

- Bing, Arthur, and George Johnson. 1966. Plant gladiolus early to reduce spread of cucumber mosaic virus. N.Y. State Flower Growers Bull. 247: 1-4.



PUBLICATIONS - STATE EXPERIMENT STATIONS

Insecticidal and Cultural Control

- Butler, G. D., Jr., and J. L. Stroehlein. 1965. The use of diazinon and fertilizers for reducing Bermudagrass mite damage and promoting grass growth. J. Econ. Entomol. 58: 783-84. (Ariz.)
- Pass, B. C. 1965. Influence of some cyclodiene insecticides on sod webworm populations. J. Econ. Entomol. 58: 586-87. (Ky.)

## PLANTING AND FERTILIZING OPERATIONS AND EQUIPMENT

Agricultural Engineering Research Division, ARS

Problem. There is a need for studies on the precise seedbed requirements for various crops; for investigations on row spacing, placement of fertilizers, and fertilizer application equipment; for precision planting studies; and for automatic transplanting equipment.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program on planting methods and means of applying fertilizer on various crops. Approximately 1.6 scientist man-years are devoted to research on fertilizer placement and distribution equipment, seed and vegetable planting equipment, and transplanting and fertilizing equipment.

### PROGRAM OF STATE EXPERIMENT STATIONS

Problems concerned with planting of the many sizes and shapes of seed of agricultural crops, together with the introduction of fertilizers for use by these crops are under attack by many of the State Agricultural Experiment Stations. A considerable amount of this work is cooperative with the Department. These studies are concerned with the development of new principles that can be used to meter and place seed which could lead to planter improvement. Similar investigations are in progress to develop satisfactory metering and placement devices for application of liquid as well as solid fertilizers. In both instances, the principal objective is to provide the best possible means of seed and fertilizer placement which will assure healthy plant emergence with vigorous growth to maturity.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### Vegetable Planting and Fertilizing Equipment.

The series of field experiments in cooperation with the Florida station on four vegetables was reduced to one in 1965 due to the plan to terminate the project as of July 1 (for the first four months of 1965). The other three studies are now being resumed for 1966.

Fertilizer placement studies and the use of an asphalt mulch spray on potatoes at Logandale, Nevada, gave no significant difference for the various treatments. Rates of fertilization were highly significant with the 200 pounds of N out yielding the 100 pounds of N. The phosphate also contributed to these higher yields. Due to restrictions on travel, the project did not actively assist in the 1966 experiment, but research equipment was made available for use by the Nevada Agricultural Experiment Station.



Experiments with cannery peas in cooperation with the Western Washington station indicate phosphorus fertilizer should be placed two inches below the seed while mixed fertilizer is better placed one-half inch to one inch to the side and one and a half inch to two inches below seed level. Treble superphosphate salt effects are noted at rates of 90 lbs.  $P_2O_5$  per acre in contact with seed; 30 lbs.  $P_2O_5$  in contact with seed gave maximum starter effect. On sweet corn, fertilizer banded 2 inches x 2 inches or 3 inches x 3 inches (side x below) from the seed was satisfactory only up to 80 lbs. N + 80 lbs.  $P_2O_5$  per acre. For higher fertilizer rates (120 lbs. N + 120 lbs.  $P_2O_5$  per acre or 160 lbs. N + 160 lbs  $P_2O_5$  per acre) the best placement was 2 inches x 4 inches or 4 inches x 2 inches.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

None

## CROP PEST CONTROL TECHNIQUES AND EQUIPMENT

Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment. Effectiveness of the equipment necessary may be essential to the success of the methods which is attempted or recommended.

Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control, and it is time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control, and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provides sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the states mentioned, unless otherwise noted.

Aircraft application equipment is studied at Beltsville, Maryland, in cooperation with the Forest Service; and at Forest Grove, Oregon, in cooperation with the Oregon and Washington stations and ENT, on low growing crops. Pest Control equipment research for certain crops is conducted on vegetable crops at Forest Grove, Oregon.

The Federal scientific effort devoted to research in this area totals 17.4 scientist man-year per year. Of this number 0.5 is devoted to insect and disease control by ground equipment in vegetables and other low-growing crops; 1.0 to insect and disease control by ground equipment to fruit; 1.3 to aircraft equipment for application of pesticides to vegetables and other low-growing crops; and 1.5 to aerial spray equipment for forest insect control.



## PROGRAM OF STATE EXPERIMENT STATIONS

Both basic and applied research investigations which have been designed to discover and develop methods, techniques, and equipment for control of the many pests that attack our economic crops are in progress at the several Agricultural Experiment Stations. Much of this work is cooperative with the Department.

These studies are involved in the complicated objectives of furthering the efficiency and the means for better control of insects, plant diseases, nematodes and weed problems through application of engineering knowledge on the use of aerial and ground chemical applicators for liquids and dusts, flame cultivators and mechanical devices for soil manipulation and soil fumigation.

A total of 7 scientist man-years is devoted to this work.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### A. Soil Fumigation.

Two of several soil treatments for control of Verticillium wilt of vegetables gave a substantial increase in yield of muskmelon, potatoes, okra, tomatoes, peppers, and eggplant. The materials used were the fumigants chloropicrin and Trizone.

A series of vegetable plots which have received the same soil treatment for nine years showed bromine injury from two compounds. Onion seedlings only lived 2 to 3 weeks or failed to develop bulbs. Potatoes failed to develop the usual number of sprouts or the plants failed to develop. Lettuce and carrot plants were also smaller in these plots. These same compounds have given the best control of root-knot nematode.

Residue analysis from turnips, sugar beets, sweet potatoes, rutabaga, radishes, potatoes, and red beets grown in soil treated with aldrin or with dieldrin, each at 2- and 3-pound-per-acre rates showed residue below allowable tolerance. The residue tolerance was exceeded in carrots for aldrin when applied at 3 pounds per acre for two years and for dieldrin at both 2- and 3-pound rates applied over a two-year period. Endrin applied at 3 and 6 pounds per acre to soil in which sugar beets and potatoes were grown produced above tolerance residue in all cases.

#### B. Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

Radishes and turnips were planted with an initial application of one pound actual insecticide per acre in the seed row, in experiments cooperative with the Ohio Center. Fourteen different insecticide treatments were made.

Seedlings were later given a drench spray of the same insecticide on a two-inch width in the row at the same dosage rate. Satisfactory commercial control of cabbage maggots was obtained on these vegetables with four of the insecticides (Bayer 25141, GC4072, Bayer 37289, VC 13). No phytotoxicity was evident in any of the treatments. Four of the treatments (Bayer 25141, Zinophos, Thimet, Di-Syston), also reduced the turnip aphid infestations to a very low population.

Cabbage, turnips, potatoes, peppers, and eggplant were treated in Ohio with ultra low volume malathion at application rates of 8, 16, and 24 oz. per acre using a sprayer fitted with compressed air atomizing nozzles, micrometer valves, and a special insecticide container to stabilize insecticide temperature. Potato leaf hopper and potato flea beetle were controlled equally well by this spray equipment applying ULV malathion in comparison with the conventional hydraulic spray equipment applying emulsifiable malathion. Control of pests (imported cabbage worm, turnip aphid, two-spotted mite, green peach aphid), on the other vegetables was either poor for applications by both types of equipment or the ULV malathion applications did not achieve control equal to the ordinary hydraulic spray applications.

#### C. Insect and Disease Control by Ground Equipment to Fruit.

A research project is getting underway at Yakima, Washington, in cooperation with ENT. In January 1966, the shell of a shop and laboratory building was completed under contract. The building is 40 ft. wide by 60 ft. long, and is of sheet metal construction on a concrete floor slab. Addition of an insulation lining, electric wiring, plumbing, a heating system, and partitioning for lavatory and an office at one end have been completed and the building is now in use.

An agricultural engineer was transferred to this project in September 1965. Some of the shop equipment has been ordered and delivered. Machines for separating codling moth pupae by size for sex, and by color for stage of pupation are under development for cooperative use with entomologists. The color separation machine uses a filtered photoelectric cell for the separation.

#### D. Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

In cooperation with the Ohio Center, measurements of spray deposits on corn made by spray equipment attached to a Bell 47 D-1 helicopter were made at flight speeds of 30 and 57 mph. Helicopter skids were three to five feet above the corn. A swath of 39 feet was used. About 50 percent of the top corn leaf area had deposits of more than five gallons per acre at 30 mph. At 57 mph only 19 percent of the top leaf area received a comparable deposit. About 86 percent of under leaf area received a 0 to 1 gallon per acre deposit at 30 mph and only about 62 percent of under leaf area received a similar deposit at 57 mph. These data indicate both spray deposit and spray penetration of the foliage of this crop decreased as application speeds of this spray applicator increased.



E. Aerial Spray Equipment for Forest Insect Control.

A spray charging device, or "electrostatic spinner", was designed and constructed at Beltsville, in cooperation with the Forest Service, for studying the possibilities of electrostatically charged sprays when applied by aircraft. Advantages that might be expected included: some degree of control of atomization, a higher percentage of spray deposited on the foliage, and a more uniform spray deposit across the swath.

An electrostatic spinner was constructed which had a water flow rate of 1-1/4 gallons per minute at 15 p.s.i. Under laboratory testing the spinner appeared to be very effective in charging the spray. This was apparent when observing the spray being attracted to nearby grounded surfaces. For field studies, four spinners were made and mounted on a Piper Pawnee airplane. Repetitive spray passes were made over a spray charge sampling station and the effects recorded. Both positively and negatively charged sprays could be produced as indicated by the spray charge sampling equipment.

Atomization studies were made at Beltsville in cooperation with the Forest Service, on the "minispin" nozzles developed by the Plant Pest Control Division for the application of ultra low volume malathion ( 3 to 16 ounces per acre) by aircraft. The atomization produced by minispin rotary units at three speeds - 4,000, 6,000, and 8,000 rpm - was compared to that produced by three flat spray nozzles - Nos. 8,002, 80,015, and 800,067. All were used on an airplane at 95 to 100 mph air speed and 40 psi spray pressure. Mass median diameter of the spray ranged from 120 microns with the minispin at 8,000 rpm, to 269 with the 8,002 nozzles. The minispin produced a lower percentage of both the fine drops and the coarse drops than did the 800,067 nozzles. The degree of atomization influences the distribution of the spray across a swath, as well as its loss due to evaporation, drift, and convection. Small drops can move laterally from an airplane to improve uniformity of the distribution - they may also increase the drift hazard. Large drops tend to fall rapidly in a vertical direction and may cause overdosing and uneven distribution.

F. Foreign Research Under Public Law 480 Funds.

In September 1964, a three-year research contract was awarded the Agricultural Research Station, Beit Dagan, Israel, to improve the penetration of insecticide spraying into the dense foliage citrus trees. Some aerodynamic studies of the vortex air jet were made in 1965 in the laboratory, and a report has been prepared containing a theoretical analysis of these laboratory studies: "Experimental and Theoretical Study of Turbulent Swirling Jets Issuing from a Round Orifice", by Nehemiah Chigier and Amnon Chervinsky, TAE Report No. 46, November 1965, 28 pages and 10 figures.

The chief purpose of the field experiments during 1965 was the establishment of a measure of performance of various existing spraying methods, in order to be able to compare them later on with a vortex air jet sprayer. One of the criteria was the determination of the depth of penetration by assessment of the spray deposit on cards. Actual tests of pest control should be included in the experiments to make the results more reliable. Some species of the armoured scales, which are the most serious pests in citrus plantations were considered but the effect of the application is very slow, and results are obtained only after three to six weeks by repeating the counts. A third criterion was taken into consideration. After harvesting, the fruits of whole test plots were graded according to their degree of contamination with scales. This additional information gave significant results in some of the tests.

The following spray equipment was used: a high-pressure sprayer with vertical boom and oscillating nozzles; an air-blast sprayer with axial flow fan and a slot around its periphery as air outlet ("speed sprayer"), delivering the air to both sides; the same sprayer, but with a hood which delivered all the air to a slot, directed to only one side; the same sprayer with the one-sided slot, and with oscillating vanes in it; an air-blast sprayer with axial flow fan, one-sided air slot, oscillating vanes and equipped with a compressor to deliver air at high pressure to atomizing nozzles, for low-volume mist spraying. Hand spraying with a spray gun at high pressure and high volume was taken as the check in most of the experiments and proved to be the most reliable method, at least under experimental conditions.

In the depth of penetration tests it was found that with the high-volume air-blast sprayers, coarse sprays penetrated significantly deeper than did the fine sprays. Changes in forward speed, on the other hand, had less influence on the depth of penetration, provided that the application rate was held constant. Application rate had to be somewhat higher with the automatic sprayers than with the spray guns. With regard to quality of coverage it was found in former investigations that at least part of the droplet spectrum should contain coarser drops in order to achieve good coverage of the fruits. In some species of orange and lemon trees, pest control with the high-volume air-blast sprayers and the vertical boom sprayer was satisfactory. In dense foliage orange trees and in grapefruit plantations results with the vertical boom sprayer were poor, with the high-volume air-blast sprayers somewhat better, and with the hand spray guns the best. The effect on pest control of the low-volume mist sprayer with air compressor was negligible. The tests will be continued and an experimental vortex air jet sprayer will be included.



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing crops.

Wilson, J. D., and Hedden, Orve K. 1965. Gallonage influences spray deposition and adhesion. Ohio Agricultural Experiment Station Report 50(3) pp 38-39. May-June.

Aerial Spray Equipment for Forest Insect Control.

Carlton, J. B. and Isler, D. A. 1966. Development of a Device to Charge Aerial Sprays Electrostatically. Agricultural Aviation 8(2). April.

Isler, D. A. and Carlton, J. B. 1965. Effect of Mechanical Factors on Atomization of Oil-based Aerial Sprays. Trans. of the ASAE 8(4) pp 590, 591 and 593.

## CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT

Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting crops and for handling of farm crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of such crops as grains and forage much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled. Harvesting equipment research for fruits, relatively recently initiated, has already resulted in sizable cost reductions, but the potential savings for these crops and vegetables are enormous.

The problems associated with harvesting and handling are interrelated with crop growing, processing, and storage thus necessitating close cooperation with engineers in other research areas and with scientists in other disciplines.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Citrus fruit harvesting research is being conducted at Lake Alfred, Florida; Davis and Riverside, California; in cooperation with the respective State Experiment Stations. Research on deciduous fruit harvesting equipment at East Lansing, Michigan; Wenatchee, Washington; and Davis, California; is cooperative with the Experiment Stations in those States, and with producers, and machinery manufacturers. Crops under study include: Apples, pears, peaches, apricots, plums, grapes, blueberries, cherries, and dates. Research on mechanical coffee harvesting is conducted in cooperation with the Hawaii Experiment Station. Potato harvesting research, cooperative with the Red River Valley Potato Growers' Association, is being conducted at East Grand Forks, Minnesota.

The Federal engineering effort devoted to research in this area totals 24.8 scientist man-years. Of this number 4.0 is devoted to citrus; 7.5 to deciduous fruit; and 2.0 to potatoes.



## PROGRAM OF STATE EXPERIMENT STATIONS

Most of the state agricultural experiment stations are engaged in some aspect of basic or applied research which is concerned with improving machines and methods for efficient harvesting and farm handling of horticultural crops. Much of this research effort is cooperative with the Department.

Detailed investigations are in progress to develop reliable mechanical harvesting and handling equipment as well as ways in which improvements might be made in crop production systems to increase yields, product quality and overall efficiency.

Current research is concerned with the diverse problems on citrus, apples, peaches, olives, apricots, cherries, prunes, cranberries, coffee, grape, pecans, cabbage, lettuce, asparagus, tomatoes, Irish potatoes, sweet potatoes, blueberries, peas and sweet corn.

During the course of these engineering investigations close cooperation is maintained with research scientists who have responsibilities for making improvements to these crops. This activity is most important in order to have machines and systems that are compatible with the new developments.

A total of 34 scientist man-years is devoted to this work in all crops.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### A. Citrus Harvesting Equipment

1. Harvesting citrus. The decreasing availability of suitable labor for picking citrus has created a serious need for improved methods and equipment for harvesting citrus fruits. Cooperative research with the Florida Citrus Commission and the University of Florida Citrus Experiment Station was continued with headquarters at Lake Alfred, Florida. A summary of the Florida work follows: Harvesting experiments on three varieties of orange and grapefruit continued (third season) with the tree-shaker-catch-frame system previously developed for citrus on this project. Three consecutive seasons of shaking the same trees have not significantly affected the fruit yields of early and midseason oranges and grapefruit and fruit removal was not materially affected by date of harvest. This prototype shake-catch equipment is ready for commercial use. Shaking force, phase angle, and limb displacement were measured on six limbs of different sizes. This information was used to develop a method of analytically determining the limb stroke from the limb size and readily measured tree shaker characteristics. Development work continued on the horizontal oscillating air-blast harvest method in cooperation with a large farm machinery manufacturer. Harvest trials were run for the third consecutive year with the same trees in the long-range program to study the effects of high velocity air on the tree and fruit. Seven different picking auger configurations were designed and molded in the development of a batch-type harvester for fresh fruit. Limited field trials were conducted to determine best spindle design for optimum fruit removal and minimum tree damage. One design looks very promising

in that a high percentage of the fruit is removed with almost no tree damage. A three to four man platform picking aid was designed and constructed for use in tree wall plantings where the trees were shaped into 6-and 8-foot thick hedgerows. A commercial one-man positioner, which the California manufacturer claimed increased picking efficiency by several hundred percent, was tested for spot-picking tangerines. A maximum increase in harvest rate of 11.7 percent was obtained using a two-man team, one in the machine and one on the ground. Several other private industry picker positioners and fruit picking aids were observed or evaluated by project personnel. Although many were ingenious and of interest, none were developed beyond the test stage. Considerable consulting and evaluation work was done by project engineers with private inventors and manufacturers who are developing fruit harvesting machines. An expanded program of pruning for mechanical harvesting and chemical fruit abscission research was carried on under contract with the Agricultural Experiment Station of the University of Florida. Iodoacetic acid loosens Hamlin and Pineapple oranges and reduces the time to shake fruit from a tree from approximately 5 to 1 1/2 minutes.

Research in California in cooperation with the University of California, growers and manufacturers was continued with headquarters at Riverside. The summary of the California research follows: A mechanical man-positioning aid called the Power Ladder was developed for fruit harvesting and tree pruning. Extensive tests have been made in both California and Arizona and showed that on lemons and oranges the unit increases picking efficiency from 30 to 40 percent. The machine is now being manufactured by a commercial manufacturer, and will possibly sell for under \$2,000. Electro-mechanically actuated power clippers were designed and constructed to be used in conjunction with a mechanical aid such as the Power Ladder. During an average day the picker clips approximately 15,000 fruit. This unit may greatly reduce fatigue which develops in the hand of the picker during the day. The unit will be evaluated next season. Three methods of using vertical pulsating air were tested. Although neither of these units had the capacity for required air velocity, the use of vertical air looks promising and further studies will be made. An experimental catching frame for use at different levels in the tree was constructed. It consists of fins spaced 2 inches apart which can be inserted into the tree. Further tests will be made on this unit. The study of the effect of applying direct current electric power through citrus trees was continued. It was definitely shown that current affects nutrient flow and that if used properly it may cause abscission, stimulate growth, retard growth, and affect the tree in many interesting ways. This work will be continued on an expanded basis. Work continued on fruit detachment devices. A snap separation device which uses several rollers is under construction. Further development on the vacuum twisting removal units was confined to laboratory studies to determine a sock design which will work on a range of fruit sizes. Drawings have been completed and shop work started on a test bank of nine units. Work on sensing devices continued. A new model of the reflected light selector was constructed and tested using photocells. By using artificial light to illuminate the tree and fruit to a more uniform level than natural light, the new model



worked satisfactorily. Possibilities of having the unit compensate for differences in natural light levels, thus eliminating the need to use artificial light, are being investigated. This selector will be used with the bank of vacuum removal units to detect and pick only ripe fruit.

Forty-two orange and grapefruit trees in major growing areas of California were surveyed for fruit location, fruit size, stem length, extent of clustering and separation force data. The orange trees were later picked and a detailed time study made of picking operations. The data have been put in a form so that it can be analyzed by a computer. Shake harvesting tests were conducted on late season Valencia and Navel oranges using an FMC limb shaker. Average removal of Valencia's was about 60 percent. About the same percentage of fruit was injured in falling through pruned trees as through unpruned trees. Approximately 3,000 fruit from each of four treatments (three shaking tests and one handpick check) were washed, treated with a fungicide, waxed and packed in shipping cartons. The percent decay for unpruned trees was twice that for pruned trees. Fruit shaken from the pruned trees had twice the decay of handpicked fruit. Percent removal from the Navel trees sprayed with 2,4-D to tighten the fruit, averaged 65 percent whereas removal from unsprayed trees averaged 80 percent. This test was performed to evaluate the effect of abscission chemicals in addition to other factors. Fruit injury tests of Navel oranges have shown that pruning out the deadwood can reduce injury by 70 percent. There is good indication that fruit can be dropped through the lower portion of the tree and possibly from higher levels with better pruning, with no more damage than would occur in handpicking. The single clip lemon clippers reported on last year were sent to Sunkist Growers. They designed a production model clipper, using the gauging and jaw design. Several hundred of these are now in use to test commercial acceptance.

#### B. Deciduous Fruit Harvesting Equipment

1. Orchard grading apples. Growers store millions of bushels of apples "orchard run." Last year over ten million bushels of undergrade and defective fruit were stored in CA or regular storage and then sorted out and sent to cider mills or other low return outlets. One possible way of eliminating this problem is to orchard grade. The experimental orchard grader was redesigned, and used to field grade McIntosh and Jonathon apples. Although the results are promising, one more year's data are needed before recommendations can be made.

2. Harvesting apples. Apples for fresh market must be picked without bruising the fruit and must be harvested at optimum maturity for long-time storage. Labor is not available to do this and machines and/or methods which will reduce labor are needed. A study of piece work rates of harvesting apples was made. This included picker variables such as sex, age, experience, and motivation and orchard variables such as tree size, fruit size, fruit density on the tree, weather conditions, and supervision. This work is being summarized and will be published in FY 1967. Once apples are detached from the trees they must be transferred to containers without

bruising. A positive flow conveyor consisting of padded counter rotating belts was developed. It can move fruit in any direction with no possible bruising whatsoever. A high capacity bin filler is also being developed which can be used in the field to uniformly fill pallet boxes without bruising. Seven methods of distributing the fruit in the bins are under test. A mobile test machine was designed and constructed for harvesting time studies in tree wall plantings. The machine moved pickers continuously past the face of fruit tree walls. One worker picks the fruit below 5 feet and the other worker picks the fruit from the 5 to 10 foot level. The fruit is placed on conveyors and moves through a bin filler into pallet boxes. The unit was used in picking tree walls of Golden Delicious and compared to hand harvesting into a bag and carrying the fruit to the bin. Picking with the machine resulted in an increase of picking efficiency of 26 percent and also made it possible for women to do the work. Component design and construction was begun on a proposed four-picker harvesting aid for 8-foot high tree walls. Upon completion of the machine, field trials will be made. This work should be of value in planning future orchard designs for maximum efficiency. Over 40 percent of the apples produced in the United States are processed. The critical shortage of harvest labor and the relatively low value of this fruit makes it imperative that harvest efficiency be increased. Two inertia shakers and a modified cherry fruit collecting unit were used to mechanically harvest over 800 bushels of McIntosh, Grime, and Greening apples. The apples were processed into applesauce. Results showed that the sauce was of equal quality to handpicked fruit. However, a large percentage of the apples needed trimming and this increased processing costs because the lines had to be slowed down (47 percent of the McIntosh needed trimming--only 14 percent of the Greenings needed trimming). Next year, two new machines will be constructed and tested. One unit will pick up apples off the ground. The other is a low-cost collection unit for shake harvesting. Apples will be harvested with both machines, processed into apple juice, applesauce or possibly apple slices. As a result of drop tests made last year a third test unit will be constructed. This will consist of an air pillow endless belt catching frame which will be evaluated for catching shake-harvested apples.

3. Harvesting blueberries. Although 70 percent of the Michigan cultivated blueberry crop and a high percentage of the crop in other states was harvested mechanically with batch-type equipment, which was developed on this project, there was still a harvest labor shortage. Principles for a continuous mechanical harvester were developed and two companies have made prototype units. Approximately a dozen of these units which will sell for \$29,000 to \$35,000 each will be evaluated in the field next season. The third year of a study on the effect on yields of how mechanical harvesting equipment is used, was completed. Results show that if the equipment is used carelessly, yields will be lowered; but if used properly, yields are about the same as those resulting from hand picking. Old blueberry bushes produced small berries and are often so tall that they are hard to harvest. Equipment was constructed to top plants at heights of 6 to 36 inches. Results achieved were disappointing in that the wood which was removed was replaced by vegetative canes which did not produce fruit and would increase harvest difficulty.



4. Harvesting tart cherries. Last year, mechanical harvesting equipment and methods which were developed on this project were used in harvesting more than 27 million pounds of tart cherries. Although the machines replaced 5,100 workers there was still a shortage of harvesting help. Average mechanical harvesting costs were \$11.70 per ton as compared to \$55 per ton for handpicking. Next season (1966) over 50 million pounds of tart cherries will be harvested with machines and it is important that quality of this fruit be maintained. Electronic sorters were evaluated and as a result of our findings several changes were made in the units which improved their effectiveness and capacity. Further work on destemming units was conducted. In cooperation with a grower, a successful destemming unit based on a new principle was constructed and tested. It will be commercially available in the 1966 season. A new procedure of handling mechanical harvested cherries was studied on a theoretical basis and recommendations made. Cherries will be soaked in the orchard, scheduled into the plant, run over an eliminator and destemmer before being weighed and graded. One processor plans to try this system and it will be evaluated. During the 1965 season an instrument for measuring firmness of cherries was developed. It will be of value in research work and could be of value at grading stations and at processing plants. Research on thermal and physical properties of tart cherries was continued. Relationships for flesh density, flesh specific heat and pit weight were determined.

5. Harvesting prunes. Mechanical harvesting methods developed on this project are now being used extensively to harvest prunes in all areas of California except the Santa Clara Valley. The California Annual Farm Labor Report showed that peak labor for harvesting prunes in 1960 was 30,300 workers, in 1965 the peak labor force was 18,000 workers. A number of growers in the coastal area are using shakers for removal for hand pick up. However, most growers are still harvesting by hand in this one area and improved methods and equipment are needed. A test was conducted to evaluate the feasibility of using a helicopter for selective removal of prunes in coastal areas. Three plots were arranged to compare the effects of different forward velocities. The helicopter was flown with the blade tips over two adjacent tree rows. Data were taken of the removal force before and after, the sugar content before and of those removed, and the percentage removal. The air velocity and frequency of pulsations per tree were insufficient to obtain a desirable removal percentage and would not be a practical method for grower use. After two passes, removal was 10 percent and was considerably less than the ground level blowers test in 1962.

6. Bark damage. Thousands of trees are being harvested with tree shakers. Trees are also being modified for mechanical harvesting. Engineering properties such as strength of both bark and wood are needed to prevent bark damage in design of shaker clamps and determining methods of shaping trees. In Michigan, the composition and strength of cherry bark was determined. Maximum longitudinal and tangential strength for the inner bark tissue was about 640 and 70 pounds per inch, respectively. The outer periderm strength was about 980 and 3,250 pounds per square inch (longitudinal and tangential).

Longitudinal cambium shear strength was about 30 pounds per square inch. In California, tests were initiated to study the seasonal variation in bark strength of prunes, almonds, peaches, and olives. Measurements were made of the tangential bark strength and bark moisture at five different periods throughout the year. Results indicate the weakest condition existed in late spring when reactivation of the cambium and fluid flow occurs. The bark is strongest during the winter months when there is no tree activity during dormancy. At the weakest point, strength is about one-half that of the strongest period (65 p.s.i. and 150 p.s.i.). During the time of harvest of early deciduous fruit crops, strength has increased to about half the strongest state and continues to increase into the winter. In Michigan, studies of the seasonal effects on mechanical properties of tree limbs and on the viscoelastic behavior of wood have been initiated. Research on improving limb shaker clamp design continued. The shock adsorbing feature incorporated in the belt-type clamp did not function properly because of friction between the rollers and shaft. The purpose was to limit longitudinal forces on the limb when shaking at bad angles with the limb. Another pad was developed to have this same feature by using a thick-soft rubber in the pad to permit relative motion between the limb and the shaker longitudinally. The design combined a curved backup surface with a flat rubber face surface. This configuration permits a more uniform radial force to the limb and centering is not critical. Field tests showed this design of limiting longitudinal shear forces to have practical application. The clamp on the trunk shaker developed in 1961 was redesigned. Four hydraulic cylinders were mounted 90° apart and were closed onto the trunk simultaneously in a radial direction. Limited tests showed this design to be satisfactory. The development and testing of a shaker to attach perpendicular to limbs was continued this year by designing a powered arm for positioning the vibrator unit on the limb. The arm consists of pivoted linkages which are actuated by rotary motors or cylinders. The motions are controlled by a single control handle which, when moved in the desired direction, actuate micro-switches which energize solenoid valves and directs fluid to the actuators. Field tests demonstrated that positioning of the vibrator unit was satisfactory. The unit is more complex than the ordinary inertia shakers and consequently more costly and slower operating. Acceptance will depend on future bark injury problems.

7. Harvesting dates. Dates grow on palm trees 30 to 50 feet high and it was necessary to replace harvest labor with machines. About 65 percent of the 1965 to 1966 crop was harvested mechanically using the bunch-cut method of harvesting and bunch shakers developed on this project. It is expected that 100 percent of the crop will be mechanically harvested next season. The savings resulting from mechanical harvesting last year was about \$210,000. The California Department of Employment reports that the peak labor in 1960 was 800 foreign workers and 90 local workers. The records show a peak of 160 workers this last year. This work was terminated in June 1965.



8. Pollinization of dates. All commercial date-producing areas in the world pollinate the female date blooms by some hand method. From three to six trips up the palm during the season are necessary. There is no attractant in the female bloom which will cause insects to bring pollen to it. Satisfactory pollination by air movement can usually be obtained if male palms are located in proper relation to female palms but the California plantings are not arranged in such a manner. This year's date crop averaged about 20 percent unpollinated (cull) fruit because pollination was not done at the proper time, during March and April, 1965, due to a labor shortage. The crop has a farm value of over \$3,000,000 and a pack-out value of over \$9,000,000. Labor aids were investigated as a method of decreasing labor requirements. The harvesting towers are not as efficient as the ladder, when used as a means of entering the palm for pollination. A pneumatic tool was designed which a worker on a harvesting tower could use to reach into the palm, open the bloom, and pollinate it. The tool was less efficient than climbing into the palm and doing the job by hand. A fixed wing and a rotary wing aircraft are now under contract and doing experimental aerial pollination work. Special equipment was designed and built for the helicopter. Glass slides in the palms are used to catch pollen samples during the flights. Twelve blocks of 40 palms each are involved in the tests. The results of this work depend upon the results of next year's crop. It is expected that the aerial pollination work will continue for the next year or two and improvements will be made, based upon the slide evaluations and resulting crops.

9. Harvesting clingstone peaches. Although principles for mechanical harvesting clingstone peaches were developed on this project several years ago, no one has made prototype equipment. The harvesting labor supply has become serious. This project has been reactivated and prototype equipment utilizing the shake-and-catch methods are being developed and will be evaluated under commercial conditions.

10. Coffee harvesting. Coffee harvesting labor outside the farm families is practically nonexistent in Kona, Hawaii. Since harvesting accounts for over 70 percent of the total farm labor input for coffee production, the grower's income is limited by the amount of coffee the farm families can harvest. Acreage has declined sharply and mechanical harvesting methods must be developed if the industry is to survive. Research on picking aids continued. A commercially manufactured hand-held blueberry vibrator was modified to increase its effectiveness in removing ripe coffee cherries. The modified unit removes fruit rapidly, but no overall conclusion can be drawn without further field testing, including fruit collection and analysis of harvested coffee for ripeness. A privately financed experimental picking aid was field tested and evaluated. The back-carried device included a pneumatic conveyor to carry fruit from the picker's hand to the container. Harvesting rate was slower than with the conventional waist-supported collecting basket. Research on complete mass harvest systems continued. Equipment consisted of a shaker mounted on a temporary transport unit, a military jeep-mounted collecting frame, and a pneumatic conveying system. This equipment operated successfully, but more extensive field testing is

required for full evaluation. Based on observations alone, more efficient operation would result if (1) the shaker was lighter in weight and would remove ripe fruit more uniformly throughout the tree, and (2) the collector frame was more maneuverable. An air-powered rotary vibration inducer manufactured commercially for use on grain and feed hoppers was tested on coffee trees. The resulting vibration was insufficient for fruit removal. Laboratory studies are underway to investigate effects of cumulative damage to the abscission points between the coffee cherries and the stem. A new shaker is under construction which will produce circular tree motion. Present collecting equipment is being modified and new equipment using a somewhat different principle is being designed. To facilitate more extensive field tests of equipment, arrangements have been made for a 0.6 acre, 300-tree orchard at the Kona Branch Station and a grower-cooperator has volunteered additional acreage. Also, a 200-tree experimental plot at Waimanalo, Oahu, Branch Station is being rejuvenated.

### C. Potato Harvesting Equipment

1. Mechanical injury of potatoes. Bruising continues to be one of the major problems in harvesting and handling of potatoes. The cantilever rubber flaps developed on this project for cushioning harvest conveyors are now commercially available. The impact instrument reported on last year for measuring potato susceptibility to bruising was used in extensive tests. The purpose of these tests was to determine methods for using the instrument so that it would be beneficial to growers. Bruising evaluations were made for five varieties of carefully dug potatoes. Also, bruising evaluations were made on potatoes obtained from commercial harvesters. An index number of the amount of mechanical damage was computed for both harvest injury and injury resulting from impact tests. This work will be summarized after harvest and a report prepared and published.

2. Multi-row harvesting of potatoes. Potato harvesters are expensive and anything that can be done to increase their efficiency or use is desirable. Multi-row harvesting methods are now being used by some growers. A comprehensive comparative cost analysis of two-row direct and four-row (multi-row) harvesting was made. This analysis indicates that multi-row harvesting can be advantageous with moderate to low yields when acreages are not in excess of 200. Owing to the substantial cost of a digger-windrower, the machinery ownership costs for harvesting machinery are increased by approximately 30 percent for four-row operation. There are also operating costs associated with the extra field operation. These additional costs must be more than offset by overall reduction of harvesting costs. This may be accomplished if the harvesting rate is sufficiently higher or a reduction in mechanical injury results in more marketable potatoes, or in a combination of these two factors. This analysis will be published early in F.Y. 1967 and should help growers determine when and when not to use multi-row harvesting.

3. Dust applicator for seed potatoes. Although dusting potato seed pieces has many advantages no commercial equipment for uniform application insuring complete coverage of the surface is available. Grower-made equipment



does not contain dust to avoid air contamination in the work area. The experimental dust applicator described in last year's report was redesigned and modified. A rotating drum was used for the treatment chamber. Instead of the dust being introduced into a high velocity air stream, it was dropped directly onto the seed pieces as they entered the drum. Air from the system was drawn through a cloth filter. The unit was given limited trials on treating 30,000 pounds of cut seed potatoes. Results showed that dust was completely contained and that the seed pieces were completely covered. The unit will be used in treating a large volume of seed potatoes in 1966 to determine maintenance and operation problems. The design will then be released to manufacturers and the results published.

4. Engineering cost study of producing and harvesting potatoes. Potato growers invested over \$10,000 for each potato harvester. Other equipment such as planters, cultivators, etc., are needed. An analysis of potato production and harvest costs for different acreage growers has been completed and a manuscript prepared for publication in F.Y. 1967. This report should be useful to potato growers in determining costs and needs and help them improve the efficiency of their potato operations.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Citrus Harvesting Equipment

- Coppock, G. E., and Hedden, S. L. 1965. Experimental harvest system for citrus. Florida Citrus Experiment Station Mimeo Services CES 66-8.
- Hedden, S. L., and Coppock, G. E. 1965. A Tree Shaker Harvest System for Citrus. Proceedings, Florida State Horticultural Society. Vol. 78.
- Hendershott, C. H. 1965. The Effect of Iodoacetic Acid on Citrus Fruit Abscission. Proceedings, Florida State Horticultural Society. Vol 78.
- Molitorisz, J. 1966. Should We Mechanize Citrus Picking? Western Fruit Grower. March.
- Molitorisz, J., and Perry, R. 1966. Development of the Power Ladder. California Agriculture, Vol. 20, No. 3. March.

##### Deciduous Fruit Harvesting Equipment

1965. Suggested Tank for Transporting Red Cherries in Water. Plan No. 611-12-34. Michigan State University Cooperative Extension Service. April.
- Adrian, P. A., and Fridley, R. B. 1965. Dynamics and Design Criteria of Inertia-Type Tree Shakers. Transactions of ASAE, Vol. 8, No. 1.

- Adrian, P. A., Fridley, R. B., and Lorenzen, C. 1965. Forced Vibration of a Tree Limb. Transactions of ASAE, Vol. 8, No. 4.
- Bennett, A. H., Saule, J., and Yost, G. E. 1965. A Prototype Commercial Forced-Air Precooler. USDA, ARS 52-9. December.
- Berlage, A. G. 1965. Harvesting Methods--Industrial Versus Mass Fruit Removal. The Goodfruit Grower 15(15): 7. August 15.
- Claypool, L. L., Fridley, R. B., and Adrian, P. A. 1965. Horticultural Aspects in Mechanization of Cling Peach Harvesting. American Society for Horticultural Science. Vol. 86.
- Fridley, R. B., and Adrian, P. A. 1965. Causes and Control of Tree Injury as Related to Mechanical Harvesting. Prune Program News, 1965.
- Fridley, R. B., and Adrian, P. A. 1965. Mechanical Properties of Peaches, Pears, Apricots and Apples. Fruchtsoft Industries. Vol. 10, No. 6. December.
- Gaston, H. P., Levin, J. H., and Whittenberger, R. T. 1966. How to Use Cherry Harvesting Machines. Michigan State University Extension Bul. 532. May.
- Gaston, H. P., Parker, R. E., Levin, J. H., Wolthuis, R. J., and Whittenberger, R. T. 1966. Developments in 1965 for Mechanical Harvesting and Handling Apples and Sweet and Tart Cherries. Proceedings, Annual Meeting Michigan State Horticultural Society. February.
- Levin, J. H. 1966. Orchard Mechanization--Improving Apple Harvesting Efficiency. Proceedings, Massachusetts State Horticultural Society. January.
- Levin, J. H. 1966. Present Status of Mechanical Harvesting of Fruit and Vegetable Crops. Proceedings, Twentieth Annual Horticultural Institute, Rio Grande Valley Horticultural Society. February.
- Levin, J. H. 1966. Harvesting Apples Mechanically. Proceedings, National Utilization Apple Conference, University of Maryland. March.
- Parker, R. E., Levin, J. H., and Gaston, H. P. 1966. Cherry Firmness and its Relationship to Pitter Loss. USDA, ARS 42-119. May.
- Parker, R. E., Levin, J. H., Whittenberger, R. T. 1966. An Instrument for Measuring Cherry Firmness. Michigan State University Quarterly Bulletin, Vol. 48, No. 3. February.



Perkins, R. M , and Brown, G. K. 1966. Date Harvest Mechanization. California Agriculture 20(2): 8-10. February.

Whittenberger, R. T., Levin, J. H., Gaston, H. P. 1965. Electronic Sorters and Destemmers for Tart Cherries Score Advances in 1964. Canner-Packer. April.

#### Potato Harvesting Equipment

French, G. W., and Blake, G. R. 1965. Primary Tillage for Potatoes. Transactions of ASAE, Vol. 8, No. 2.

#### Tobacco Harvesting Equipment

Yoder, Elmon E., and Smith, E. M. 1965. Handling Stalk-Cut Tobacco on Portable Curing Frames. Journal of American Society of Agricultural Engineers, Vol. 46, No. 12. December.

### PUBLICATIONS -- STATE EXPERIMENT STATIONS

#### Deciduous Fruit Harvesting Equipment

Booster, D. E., and Bullock, R. M. 1965. Mechanical Harvesting of Cane Fruits. Transactions of ASAE, Vol. 8, No. 2.

Diener, R. G., Mohsenin, N. N., and Jenks, B. L. 1965. Vibration Characteristics of Trellis-Trained Apple Trees with Reference to Fruit Detachment. Transactions of ASAE, Vol. 8, No. 1.

Fletcher, S. W., III, Mohsenin, N. N., Hammerle, J. R., and Tukey, L. D. 1965. Mechanical Behavior of Selected Fruits and Vegetables Under Fast Rates of Loading. Transactions of ASAE, Vol. 8, No. 3.

Fridley, R. B., and Lorenzen, C. 1965. Computer Analysis of Tree Shaking. Transactions of ASAE, Vol. 8, No. 1.

Gentry, J. P., Mitchell, F. G., and Sommer, N. F. 1965. Engineering and Quality Aspects of Deciduous Fruits Packed by Volume-Filling and Hand-Placing Methods. Transactions of ASAE, Vol. 8, No. 4.

Jacob, F. C., Romani, R. J., and Sprock, C. M. 1965. Fruit Sorting by Delayed Light Emission. Transactions of ASAE, Vol. 8, No. 1.

LaBelle, R. L., Markwardt, E. C., and Guest, R. W. 1965. Improving the Processing Quality of Mechanically Harvested Apples. Transactions of ASAE, Vol. 8, No. 2.

Lamouria, L. H., and Brewer, H. L. 1965. Determining Selected Bio-Engineering Properties of Olives. Transactions of ASAE, Vol. 8, No. 2.

- Mohsenin, Nuri N. 1965. Physical Properties of Agricultural Products. Transactions of ASAE, Vol. 8, No. 1.
- O'Brien, Michael, Gentry, J. P., and Gibson, R. C. 1965. Vibrating Characteristics of Fruits as Related to In-Transit Injury. Transactions of ASAE, Vol. 8, No. 2.
- Wang, Jaw-Kai. 1965. Mechanical Coffee Harvesting. Transactions of ASAE, Vol. 8, No. 3.

Vegetable Harvesting Equipment

- O'Brien, Michael and Lingle, John C. 1965. Mechanical Harvesting of Cantaloupes. Agricultural Engineering 46(2): 75-77.
- Perry, J. S., and Hall, C. W. 1965. Mechanical Properties of Pea Beans Under Impact Loading. Transactions of ASAE, Vol. 8, No. 2.



## STRUCTURES FOR CROP AND MACHINERY STORAGE AND PLANT GROWTH

Agricultural Engineering Research Division, ARS

Problem. The magnitude and scope of the crop and machinery storage problem is evidenced by the vast quantities of crops and other materials handled and stored on the farm. Annually on the farm nearly 2.5 million bushels of apples and pears and 34 million hundred-weight of potatoes and sweet potatoes are held for food, feed and seed; and other large quantities of fruits and vegetables are held for temporary storage pending marketing.

Plant growth structures can represent investments ranging from a few hundred to several million dollars depending on their nature and scale. Controlled environment growth chambers range from \$1000 to \$50,000, controlled environment greenhouses from \$2000 to \$700,000, and phytotrons from \$400,000 to \$5,000,000. During the last four years, the USDA has spent about \$500,000 per year for growth chambers. No overall expenditure figures are available.

The 1959 census showed 227 million square feet of commercial greenhouse area in the United States. Of this area, 83% is used for florist crops, 4% for nursery crops, and 13% for vegetable crops. Greenhouse produced crops equal 2% of all farm products sold.

### USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program involving engineers and architects engaged in both basic and applied research and the development of typical plans for storage and plant growth structures. The Federal effort in this research area totals 2.4 scientist man years.

### PROGRAM OF STATE EXPERIMENT STATIONS

The complicated problems associated with providing protection to the products of agricultural production as well as the machines, equipment, and service facilities which are required for such production has necessitated a continuing program of research at the State Agricultural Experiment Stations.

The current broad scale program is concerned with curing, bulk handling, and storage for onions; Irish potato and sweet potato plant production facilities and storages; controlled atmosphere storages and construction methods; designs and construction of plant growth chambers and plastic greenhouses; and many other problems.

Much of this research activity is cooperative with the Department.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Plant Growth Structures.

1. Phyto-Engineering Laboratory. Considerable effort was devoted to planning, developing and generally overseeing construction of a new research facility at the Plant Industry Station, Beltsville, Maryland. It consists of a 1-1/2 story building 72' x 36', containing offices, laboratories for engineering and plant physiology studies, and space for construction and testing growth chambers. An 80' x 100' concrete platform for greenhouse research studies is attached to the rear of the building.

The building and facilities will be used to study both engineering and plant physiological problems; hence the name Phyto-engineering.

2. Carbon Dioxide Studies. Studies were conducted on a preliminary basis with CO<sub>2</sub> in gaseous and carbonated water forms during the year to test out new equipment and controls and to develop a sound cultural practice for growing various types of plants in a completely controlled environment. In the CO<sub>2</sub> gas studies seeds of several annual flowers were germinated and grown to the flowering stage. Growth (wet. wt.) in the controlled chambers was as much as 100 times of the same

3. Portable greenhouse. A temporary, self-contained, portable greenhouse was developed to provide a temperature and humidity controlled area in a remote portion of a pear orchard at the Plant Industry Station, Beltsville, Maryland. The facility was needed by the Crops Research Division to meet a requirement of 70°F temperature and high humidity for inoculating pear seedlings with fine blight bacteria. A fan and pad system is used to keep the humidity at a high level. In addition, spray nozzles are used inside the greenhouse to further increase the humidity and to wet the plants. A bottled gas motor generator furnishes electric power for the fan and pumps. Water is supplied by a tank that has to be filled periodically. The generator is started manually early in the morning when water supply and other equipment is checked, and shuts off automatically at a preset time. It has worked quite well and shows great promise for similar applications.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None



PUBLICATIONS -- STATE EXPERIMENT STATIONS

Hunter, J. H., and Toko, H. V. 1965. Control of Potato-Storage Disease as Affected by Air Flow, Temperature and Relative Humidity. Trans. of the ASAE. 8(4), pp. 578-580.

Neubauer, L. W., Hoyle, B. J., and Kucera, E. 1965. Effect of Methods of Storage on Subsequent Growth and Yield of Seed Potatoes. Trans. of the ASAE. 8(1) pp. 138-140.

## ELECTROMAGNETIC AND ULTRASONIC ENERGY FOR INSECT CONTROL

Agricultural Engineering Research Division, ARS

Problem. To minimize the use of possibly hazardous chemicals and their residues in food products as much as possible, there is need for widespread investigation of non-chemical pest control methods, such as study of insect response to all possible types of radiation and sound and exploitation of weak physical links in the life of particular insects. There is need for development of better electric insect survey traps to sample insects in flight, and to permit control programs to be timed with greater accuracy. There is need for detecting or removing insects in food processing plants, including fruit flies in tomato canning plants, and larvae of the cabbage looper and imported cabbage worm that may be clinging to spinach leaves when delivered to the processing plant. The promising results of a project to control tobacco hornworm with only three traps per square mile using ultraviolet radiation as the attractant in a newly designed blacklight insect trap has raised the question, "What other insects can be controlled by electrical methods and equipment alone or in combination with insecticides, chemosterilants, and biological attractants?" Production of many crops is hampered by poor, slow, or non-uniform emergence of seedlings after the seed is planted. Some electrical treatments have been found to accelerate germination and seedling emergence. If emergence in the field can be speeded up and better uniformity obtained, weed control can be much more effective, with resulting increased efficiency in production of crops. Treatments also increase the percentage of germination for some seeds and would therefore enable the establishment of good stands with lower investments for seed. Further, uniform emergence tends toward more uniform saturation and increased practicability of once-over harvest programs.

### USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of basic and applied research involving agricultural and electrical engineers and physicists working cooperatively with USDA entomologists and with the State Experiment Stations. Research on electrical and physical methods of vegetable insect control and light trap design is conducted in California and Indiana, with financial assistance from the Indiana Electric Association through the Purdue University Experiment Station.

Studies relating to potential use of radiofrequency (RF) energy for insect control and improvement of seed germination are in cooperation with the Departments of Agricultural Engineering, Entomology, and Agronomy at the Nebraska Agricultural Experiment Station. Cooperative help on some phases of studies was furnished by the Crops Research Division, ARS, the Asgrow Seed Company, the Agricultural Engineering Departments of the University of Idaho and Texas A & M University, and others.



The Federal scientific effort devoted to Agricultural Engineering research in this area totals 11.3 scientist man-years; of this number 5.8 are devoted to electric traps for insect survey, destruction and control; 0.8 to components and design of electric insect traps for survey and control; 1.0 to sonic and ultrasonic energy for insect control; and 0.7 to program leadership.

#### PROGRAM OF STATE EXPERIMENT STATIONS

Several of the States are engaged in programs of basic and applied research on the possible use of some of the various forms of electrical and physical energies as a means for improvement of the potential capabilities in farm production. Investigations in progress, many of which are cooperative with the Department, include the evaluation of the use of light sources of various wavelengths for attracting and collecting insects which infest many of our economic crops.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Electric Traps for Insect Survey, Destruction and Control

##### 1. Electric Traps for Vegetable Insects

At Lafayette, Indiana, research on the development of equipment for attracting and destroying insects with electric energy was continued in cooperation with the Departments of Agricultural Engineering and Entomology of the Purdue University Agricultural Experiment Station. The work was supported in part by the Indiana Electric Association. Migration and occurrence of corn earworm moths and the occurrence of several other insect species of economic importance were studied in cooperation with personnel of the Purdue Department of Entomology as a part of Regional Project NC-67, Migration of Aphids and Noctuids. Field experiments were expanded and continued for the eighth consecutive season to investigate the effectiveness of electric insect traps for controlling insect damage in tomato production. Species whose damage to tomatoes might be reduced through use of light traps include the tobacco hornworm, Manduca sexta (Johannson), tomato hornworm, Manduca quinquemaculata (Haworth), tomato fruitworm or corn earworm, Heliothis zea (Boddie), various cutworms, and drosophila. Effectiveness of control was studied relative to distance and direction of plants from two light traps in the field plot. The traps were equipped with five 15-watt fluorescent blacklight lamps and a fan mounted between the trap funnel and collection container. Light traps were the only insect control measure used to protect the tomatoes. Damage in the field with light traps was compared to a similar planting without light traps about 2,000 feet away.

Insect-infested plants, ripe fruit damage, and trap catches were used as indicators of the effectiveness of light traps in controlling insect damage to tomatoes. As in 1964, hornworm infestation near the traps was substantially reduced. Hornworm infestation in the field equipped with traps

was delayed about 6 weeks, as compared to the planting without traps. No tomato varietal differences were noted in degree of hornworm control. Maximum distance of plants from a light trap in the field protected with light traps was 532 feet. Hornworm damage in this field was generally lower than that observed in the unprotected field. On August 10, 12 percent of the plants in the light-trap field were infested compared to 54 percent in the unprotected planting. On September 7, 57 percent of the plants in the light-trap field were infested compared to 99 percent in the unprotected field.

No drosophila infestation occurred in either field, and tomato fruitworm damage was negligible. Damage to fruit caused by insects other than hornworms, primarily cutworms, was uniform throughout both fields. No appreciable control for cutworms was effected either in 1964 or 1965.

Results of experiments over the past few years indicate that hornworm and tomato fruitworm damage to tomatoes can be substantially reduced by the use of blacklight insect traps. No differences in infestation were noted due to differences in direction of the plants from the traps. Because of protection which light traps have provided cucumbers from cucumber beetles in past work, further experiments are planned to study the possibility of using an integrated insecticide and light-trap program to control these insect pests in 15- and 32-acre, commercial-sized plantings. Objectives of the new experiments are twofold: (1) To perform a basic scientific study in a commercial planting to confirm or deny earlier experimental results in small plots, and (2) to demonstrate the use of insect traps to potential users.

At Riverside, California, work was conducted in cooperation with the University of California and the Entomology Research Division (ENT), ARS on a new project to study methods of utilizing electric energy in controlling vegetable insects. Blacklight insect traps were installed near Riverside, and tests were run to determine their effectiveness in attracting cabbage loopers, Trichoplusia ni (Hübner). Light traps with virgin females confined in cages on the traps caught up to 40 times more male cabbage loopers than traps with no females. On the average, 10 times more males were caught in traps with virgin females than in traps without them. Location of virgin females within 40 feet of light traps effected increased light trap catches of male cabbage loopers. Effectiveness of the same confined female moths in increasing light trap catches continued for at least 2 weeks without decline. The number of moths caught in the traps was not affected by confined male cabbage loopers at the traps or by virgin females when dispersal of the female sex pheromone was prevented. A trap equipped with virgin females as the only attractant caught approximately the same number of males as traps equipped with a blacklight lamp as the only attractant. Studies involving the release of 17,000 marked laboratory-reared moths showed that 8.4 percent of these moths were recovered in traps in the release area. A few moths were captured 10,000 feet from the release point; however, 93 to 100 percent of those captured were caught within 1 mile of the release point. Based on promising results of this year's data, a large



field-trapping installation will be installed in Arizona in an attempt to reduce cabbage looper infestation. In an effort to apply chemosterilants to insects, light traps were modified to permit captured moths to escape after contacting the chemosterilant. The method worked well in the laboratory, but was not successful in the field because small insects, dust, and high temperatures adversely affected the chemosterilant-treated surfaces. Preliminary investigations were conducted at Charleston, South Carolina, to determine potential usefulness of light traps in work with the southern potato wireworm, Conoderus falli Lane. Work there will be continued on about the same basis with AE participation limited to advising ENT personnel on the use of electric traps.

## 2. Electric Traps for Fruit and Nut Insects

In cooperation with ENT, ARS, preliminary investigations were conducted at Yakima, Washington, on the codling moth, Carpocapsa pomonella (Linnaeus). Potential usefulness of light traps for control of this insect has been indicated in several earlier studies, and work at Yakima will be expanded to further explore possibilities of light traps for codling moth control. Preliminary experiments were also conducted at Albany, Georgia, to explore possibilities of using light traps for pecan insect control. Results were encouraging, and experiments using light trap installations for pecan insect control will be studied further in 1966.

### B. Components and Design of Electric Insect Traps for Survey and Control

In field studies, light traps equipped with a fan and five 15-watt BL lamps caught about twice as many corn earworm moths as the gravity-type survey traps with one 15-watt BL lamp as the attractant. Males and females were caught in equal numbers. Using traps equipped with a device to separate the catch for different time intervals during the night, field studies were conducted on the nocturnal activity of the corn earworm, tobacco hornworm, tomato hornworm, and variegated cutworm, Peridroma saucia (Hübner), and the yellow-striped armyworm, Prodenia ornithogelli Guenee. Catches of corn earworm moths through the night were nearly uniform from an hour after sunset until an hour before sunrise. Tomato hornworm moths were captured primarily in the early morning hours, while tobacco hornworm moths were captured at equal rates from sunset until an hour before sunrise. The male-to-female sex ratio for tobacco hornworm moths was 4:1 and 3:2 for tomato hornworm moths. The corresponding sex ratio for the variegated cutworm was 3:2, and these moths were captured uniformly from sunset until an hour before sunrise. Sex ratio for the yellow-striped armyworm was 2:1. These moths were captured in greatest numbers during the early morning hours.

### C. Radiofrequency and Glow-discharge Energy for Insect Control and Seed Treatment

#### Vegetable and Ornamental Seed Studies

In the previous 3 years, RF treatment of spinach seed has provided an acceleration of germination and emergence from soil in some tests. This year, in

cooperation with Dulany Foods, of Fruitland, Maryland, two varieties of spinach seed were treated with RF energy and returned to Maryland for field testing. Laboratory tests of germination conducted by Asgrow Seed Company revealed acceleration of germination for both varieties; however, early emergence in field tests was improved for only one variety.

In preliminary experiments with RF electrical treatment of seed of some ornamentals, increased germination due to treatment was obtained for some low-germinating lots of cosmos, ipomea, and Bells of Ireland.

In other preliminary work cooperative with CR, ARS, personnel at Texas A & M University, germination of mesquite seed was improved by RF treatment, but these treatments failed to increase germination of yaupon, huisache, and McCartney rose seed.

Additional experiments are planned to study the effectiveness of different combinations of variables in reducing hard-seed content and in improving the germination of horticultural crop seed.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Electric Traps for Insect Survey, Destruction, and Control

Deay, H. O., Barrett, J. R., Jr., and Hartsock, J. G. 1965. Field studies of flight response of Heliothis zea to electric light traps, including radiation characteristics of lamps used. Proceedings, North Central Branch, Entomological Society of America. 20:109-116.

Earp, U. F., Stanley, J. M., and Lam, J. J. 1965. Spectral response of hornworm moths. Transactions of ASAE. 8(2):183-185.

Earp, U. F. and Stanley, J. M. 1965. Spectral response of hornworm moths. Conference Proceedings: Electromagnetic Radiation in Agriculture. pp. 25-27. October.

Henneberry, T. J., Howland, A. F., and Wolf, W. W. 1965. Blacklight traps for control of cabbage loopers. Conference Proceedings: Electromagnetic Radiation in Agriculture. Illuminating Engineering Society and the ASAE. pp. 34-35. October.



## ELECTRIC AND SOLAR EQUIPMENT FOR ENVIRONMENTAL CONTROL

### Agricultural Engineering Research Division

Problem. Special controlled environments are necessary for the proper conditioning of crops like sweet potatoes, and are extremely effective in maintaining the quality of stored fruits and vegetables. Current scientific and economic developments indicate that production of vegetables and flowers in the future may require complete control of soil, light, and atmospheric conditions. Engineering problems associated with the application of light to plants have increased in recent years with the need for growth rooms for research and commercial use of light for growing crops.

### USDA AND COOPERATIVE PROGRAM

A program at Beltsville has been established whereby engineers from the Agricultural Engineering Division cooperate with Crops Division scientists on basic studies of light and thermal environment and their relation to plants in growth chambers.

Equipment for the application of carbon dioxide to plants is under development at Beltsville and at Kansas State University in cooperation with the Departments of Agricultural Engineering, Horticulture and Physics. Performance characteristics of equipment are being studied for maintaining environment for conditioning potatoes for processing in cooperation with the Departments of Agricultural and Chemical Engineering, Horticulture and Plant Pathology of the University of Minnesota and the Market Quality Research Division and the Transportation and Facilities Research Division, ARS, East Grand Forks.

The Federal scientific effort devoted to research in this area totals 4.7 scientist man-years; of this number 1.8 are devoted to plant environment equipment.

### PROGRAM OF STATE EXPERIMENT STATIONS

The State agricultural experiment stations are engaged in extensive basic and applied research to extend the advantages of controlled environment to all phases of agriculture in order to obtain maximum economic growth, production, product preservation, and product quality. Studies of the possibilities for use of solar energy as well as electric energy to achieve the broad scale objectives are a part of the total program. Among the several investigations involved in these programs are determination of the effects of soil, light, and atmospheric conditions on plants; and temperature, humidity and gases on stored products.

A great portion of this research is cooperative with the Department.

A total of 3.5 scientist man-years is devoted to this work.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Plant and Product Environmental Equipment

1. Carbon Dioxide Fertilization

At Beltsville, studies were conducted on a preliminary basis using new equipment and controls to develop a sound cultural practice for growing various types of plants in a completely controlled environment with CO<sub>2</sub> enrichment. Seeds of several annual flowers were grown from germination to the flowering stage in the greenhouse with supplemental light treatments and in controlled artificial conditions. These conditions consisted of normal temperature (65°-75° F.) and humidity (50-70%) with 2200-2400 ft.-c. of fluorescent and incandescent light for 16 hours of each day. One chamber had uncontrolled CO<sub>2</sub> at about 400 ppm (near atmospheric) while the other was controlled at approximately 1000 ppm. Results of a typical test of growth for a 2-week period are shown on following table. In all instances, the growth in the controlled chambers was much faster and for most plants the flowering was earlier.

Typical Experiment:

Environment	Weight of seedling			
	2 weeks after start of treatment			
	Petunia Pink Cascade	Ageratum Blue Blazer	Marigold Double Eagle	Snapdragon White Rocket
<u>Greenhouse</u> - 65° Night Temperature	mg	mg	mg	mg
1. 8-hr. day - 16-hr. dark	15	15	203	12
2. Natural days (ND) Feb.	14	13	254	10
3. ND + continuous incandescent (80 ft.-c.)	18	16	206	13
4. ND + continuous fluorescent (250 ft.-c.)	65	42	800	43
<u>Growth Room</u> - 65° Night Temperature				
5. 16-hr. day - 400 ppm CO <sub>2</sub>	600	500	4600	358
6. 2200-2400 ft.-c. fluor. & incand. light - 1000 ppm CO <sub>2</sub> av.	3100	1300	12600	900
Ratio: Treatment 6 ÷ treatment 1	206	86	60	75



Plant seeded - 1/28/66

Light treatments - 2/4/66 - 2/18/66

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Geraniums grown from seed that normally flower in 18 weeks were flowering in 8 weeks. Petunias normally take 8 weeks or longer, but some with CO<sub>2</sub> fertilization flowered in 35 days.

In Kansas, a system for misting carbonated water has been designed and installed. The controls will provide adjustment of misting cycles over a range of 2 seconds up to continuous application. A control sensitive to sunlight intensity is also part of the system.

## 2. Plant Growth Lighting, Radiation, and Instrumentation

At Beltsville, the angle transducer has been incorporated to use 10 plant movement sensors through a timed stepping switch to a single-point recorder which records each point for 1 minute out of 10.

Preliminary studies were conducted to develop and test a new technique for greenhouse cooling. In this study preconditioned air was passed between two layers of greenhouse covering to determine how much of the radiant energy can be removed before it enters the greenhouse. Tests were conducted on various materials to determine their ability to pass visible light and their capacity to remove infrared radiation. Solar radiation was simulated by using reflector incandescent lamps. Single and double layer tests were conducted with conditioned air passing between the double layers. Radiation between 1/4 and 2 micron wavelength was measured and preliminary tests indicate that a significant part of the radiant energy of incandescent lamps can be removed while reducing the light only 10-20 percent.

Assistance was given the Crops Research Division in preparing the Bulletin and in designing and constructing the planters, for the publication "Indoor Gardening for Decorative Plants".

## 3. Environmental Equipment for Potato Conditioning

In Minnesota, cooperative research is underway to develop equipment for storing and conditioning potatoes so they will be available for processing as much of the year as possible. An experimental refrigeration system has been developed that will store potatoes for up to 9 months without need for defrosting thereby eliminating undesirable conditions due to defrost cycles.

The new system includes an oversize evaporator that operates with only a small difference between air and refrigerant temperatures. This eliminates frost accumulation on the coils, a condition which seriously impairs refrigeration efficiency, especially at the high humidity desired for potato storage. Defrosting cycles, an automatic feature of many conventional refrigeration systems, adds heat to the room or may reduce humidity to a level where an auxiliary humidifier is needed.

The ARS-Minnesota experimental refrigeration system held six potato varieties within 1-1/2 degrees of 40 degrees F.--a high level of precision--at relative humidities of 85 to 95 percent, for up to 9 months. After a 4-week conditioning period at 65 degrees F. to burn up sugars that would otherwise give the potato flakes a scorched taste, Bounty, Irish-Cobbler, Kennebec, Norgold, Red Pontiac, and Snowflake potatoes gave acceptable instant flakes. Potatoes processed directly from 50-degree storage in other tests, consistently gave more white flakes.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None